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ORIGINAL ARTICLES.

I.—Secular Earth-Creep.

By Professor E. H. L. Schwarz, A.R.C.S., F.G.S., Rhodes University College, Grahamstown.

DR. J. R. SUTTON has recently read a most important paper to the Royal Society of South Africa on the diurnal variation of level at Kimberley. The paper gave the preliminary results of observations made during the course of three years upon the variation of the level of the ground as recorded by a large horizontal pendulum of a special design made for the author by the Cambridge Instrument Company. It appeared from the results that the movements in the surface of the ground, which set up corresponding movements in the pendulum, were very great. The maximum westerly elongation of the extremity of the pendulum occurred about 5.30 a.m., the maximum easterly about 1.15 p.m., the medium positions a little before 11 a.m. and 9.30 p.m. Geometrically these movements may be represented on the hypothesis that the hemisphere facing the sun bulges out, forming a sort of meniscus to the geosphere. The rise and fall of the surface of the ground which such a supposition would postulate is enormous, and the very magnitude has led Dr. Sutton to hesitate in giving the figures. There can, however, be very little doubt that some rise and fall in the earth's surface is occasioned by the sun's gravitational pull, although the present figures may have to be lessened by taking into consideration other causes which contribute to the disturbance of the pendulum.

The subject is not a new one; Professor Milne, in his Bakerian lecture, referred to experiments he had carried out at Shide, Isle of Wight, in which it was proved that the earth's surface bulged on a sunny day and was depressed on a cloudy or rainy day; the cause for this was the different rates of transpiration in the leaves of the trees, grass, and so forth, which led to the accumulation of water in the soil on a cloudy day sufficient to weigh down the earth. Such elevations and depressions, however, leave no permanent distortion, but when the earth is day by day pulled out towards the sun, this must in the course of geological periods cause the ridges in the earth's crust to creep westwards.

In the Devonian rocks we have in South Africa a peculiar assemblage of forms characterized by a small Brachiopod, *Leptocœlia flabellites*, Conrad. When these were first sent home by A. G. Bain, Rupert Jones at once wrote back saying that they were the same as the fossils then recently brought back from the Falkland Islands by Charles Darwin. Recent work has proved the correctness of this view, and not only in the Falkland Islands, but the Lower Devonian fossils from the Argentine, Brazil, and Bolivia in South America, and the eastern portion of North America, are remarkably alike, and, on the other hand, as remarkably distinct from the European Devonian fossils.

To make sure that our South African fossils were identical and not merely similar to the North American forms, I submitted a small series from the Bain Collection in the Albany Museum, Grahamstown, to Dr. J. M. Clarke, who very kindly examined them and replied as follows:—

"The specimens of *Leptocœlia flabellites* are entirely in accord with the usual expression of this species as it occurs in the New York Oriskany, the Gaspé sandstone of Eastern Quebec, and the Lower Devonian sandstone of Central and Southern Brazil and of the Falkland Islands. There are some variations in this species which might upon close analysis serve to exhibit definite stratigraphic or time values. We find, for example, in certain Oriskany beds in this State multitudes of more diminutive forms which seldom attain the normal average size as expressed by your South African specimens. On the other hand, in the Grand Grève limestones of Eastern Quebec the species attains quite extraordinary dimensions, and it is interesting to observe that this large size is reached in a calcareous facies, and the same effect is noticeable in other Eo-Devonian species which are most commonly known in the arenaceous sediments."

A large part of these Lower Devonian strata are sandstones with shales and limestones interbedded, and the whole aspect of the series is that of a shore deposit. I cannot speak of the direction from which the sediment was carried except in South Africa, where the sandy beds occur towards the north, and their place is taken by shale beds to the south, and there can be no question, therefore, that the land in these times lay to the north. We can, however, plot roughly the shore-line of this ancient continent on the south and western shores. In the north we know very little yet of the beds; the actual shore-line is submerged beneath the ocean in Europe, and in North Africa the exposures in the Sahara are too isolated and as yet not sufficiently explored to enable one to plot the shore-line. It is true that Professor E. Haug has described two characteristic South African fossils, including *Leptocœlia flabellites*, from Tassili in the French Soudan, which were brought back by the Foureau expedition. I have, of course, only seen the photographs published with the description of these beds, but the fossils do not to my mind resemble the South African ones. However, accepting Professor Haug's determinations, the occurrence of the *Leptocœlia flabellites* fauna in the Soudan would indicate that an inlet of the shore of the Devonian Atlantis passed somewhere in the neighbourhood. The rest of the Saharan Devonian fossils are plainly European, and suggest that there was no

connection of the European Devonian ocean with the American and South African Devonian ocean such as the Tassili fossils, according to Professor Haug, should indicate.

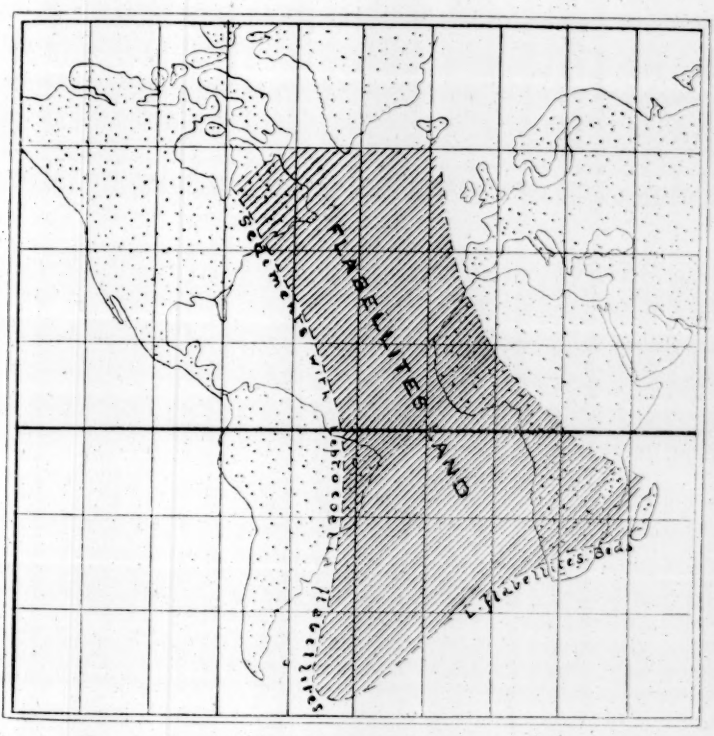


FIG. 1.—Map showing the distribution of land and water in the Atlantic region during early Devonian times; from Trans. Phil. Soc. S.A., Cape Town, 1905, vol. xvi; see also F. Katzer, Bol. d. Museu Paraense, 1895, vol. ii, map to face p. 237.

Taking only the southern and western shores into account, it is manifest that there was a land-mass occupying the area of the Atlantic in Lower Devonian times of somewhat similar dimensions to that of the Americas. Has Dr. Sutton's investigation at Kimberley any connection with this? The facts are very suggestive taken into account with the later Lemuria, which occupied the Indian Ocean closer to Africa than the earlier *Flabellites* land did to America. I do not wish to strain the point at present as it is a new one, but I wish to draw attention to Dr. Sutton's work, which appears to me pregnant with important bearing on questions of earth physics. If this earth creep westwards is established, it will be the deathblow to the Tetrahedral theory, for it will provide for a continuous obliteration of earth features in the direction of the earth's revolution, and there are no forces within the earth to reproduce the tetrahedral edges, which are supposed to

have originated by the collapse of the shell in the shrinking nucleus of the globe, once these have been flattened out longitudinally by this earth creep.

The subject first suggested itself to me when working on the rocks of Tristan da Cunha, and the map here reproduced is taken from my paper on "The Rocks of Tristan da Cunha brought back by H.M.S. Odin, 1904, and their bearing on the question of the Permanence of Ocean Basins".[1] Dr. Katzer, in his "A fauna devonica do rio Maëcuru, e as suas relações com a fauna de outros terrenos devonicos do globo",[2] drew his "Continente atlantico-aethiopico" on more or less the same lines, but terminated it to the south by a shore running latitudinally, parallel with the southern extremity of South Africa, deriving his sediments in the Falkland Islands from a "Continente meridional". The sediments in the Falkland Islands, however, are so similar to those in the Bokkeveld Beds in South Africa that I am inclined to think they must have been derived from the same continent. The important point to notice is that Dr. Katzer, working from Brazil, arrived at the same distribution of land and water in Devonian times as I did working from the other side of the Atlantic.

II.—On the Jaw Apparatus of *Discoidea cylindrica* (Lamarck).

By Herbert L. Hawkins, B.Sc., Mark Stirrup Scholar in the University of Manchester.

(PLATE VI.)

Whilst searching through the duplicate drawers in the Manchester Museum I found recently a specimen of *Discoidea cylindrica* which contained the dental apparatus in a very good state of preservation. The softness of the matrix within the test made it possible to develop and extract the jaws, and thus to detect several new features of interest.

The jaws of *Discoidea* were described in 1892 by Lovén, who gave good figures of the maxillæ both in the text (p. 53) and on plate x (figs. 114, 115). In this paper he discusses the two distinct types of perignathic girdle that occur in *Discoidea cylindrica*. He states that in the depressed form (*forma vulgaris*) the ambulacral processes ('aurieles') are low, and connected by interradial ridges ('walls') which are of almost the same height; whereas in the tall form (*forma elatior*) the processes are much more prominent than the ridges. The jaws he describes are from the form he designates as the "more normal", but it is hard to determine to which type he refers in this phrase. There is no mention of the teeth or of the epiphyses in Lovén's paper, but both these structures are preserved in the specimen about to be described.

It will, perhaps, be best to proceed with the description of the specimen, and subsequently to consider the differences from Lovén's description.

The specimen, which is one of a pair of small *Discoideæ* collected

[1] Trans. Phil. Soc. S.A., Cape Town, 1905, vol. xvi, p. 19.
[2] Boletin do Museu Paraense, 1895, vol. ii, Para, Brazil.

by the Rev. A. Dixon from the Lower Chalk of Sewell, in Cambridgeshire, is what would be usually described as a young form, the cylindrical character of the sides of the test of adult forms being scarcely perceptible. The dimensions of the test are: Breadth of base, 38·75 mm.; height of test, 22·25 mm. At one point the test was broken away, and by careful development sufficient was removed to expose the five pairs of hemi-pyramids with their teeth, all lying in the left anterior interradius (Fig. 1).

The *maxillæ* are small and lanceolate in form, with their adoral ends strongly curved inwards. The inter-pyramidal joint-face (Fig. 3) is broad, being 6·6 mm. long and 3·2 mm. wide at its greatest breadth, which extends from about 2 mm. above the oral end, almost to the aboral end of the face. Its aboral margin slopes very slightly outwards and downwards. The transverse ridges are almost parallel to the aboral margin; they are straight and very fine, being about seven to each millimetre. The *fossa arcualis* is high, and about ·75 of the breadth of the aboral margin of the inter-pyramidal face. The outer surface (Fig. 2) is slightly narrower, and strongly convex adorally. Its length is 8·1 mm. and its greatest width 3·1 mm. The external margin is sharp and elevated into a flange. The admedian outer plane is very narrow aborally, but becomes widened into an inward sloping plane, 1·0 mm. wide adorally. It crosses the marginal flange, and is continued as a strongly incurved process for about ·75 mm. beyond it. The *fovea magna externa* is narrow and deep below, with a distinct facet on the outer side of the admedian plane, but it rapidly becomes shallower upwards, and, save for a slight depression aborally, it forms a broad, somewhat concave surface. The symphysial face is narrow (·9 mm. wide near the upper end), becoming somewhat broader at the incurved adoral end. The length of the symphysis is 5·4 mm. (chord measurement), and the full height of the maxilla is 8·1 mm.; the ratio of symphysis to maxilla is therefore ·67. The internal face has a deep concavity partly divided by a carina at the aboral end. The dental slide is concave and rather deep. It extends to within ·6 mm. of the angle of the supra-alveolar process. The adoral region of the internal face is smooth.

The *epiphysis* (Fig. 6) is very minute and slender. Its horizontal length is 2·7 mm., its height at the outer end 1·5 mm. It is reduced to a narrow bar towards the inner end. The inter-pyramidal surface is horizontally ribbed, with a rounded prominence at about 1 mm. distance from the inner end. The surface of articulation with the maxilla is almost smooth.

No recognizable trace of a *rotula* or of a *compass* can be determined, but the rounded prominence on the epiphysis indicates the existence of a rotula, as this articulation is the chief one between these two pieces in most Regular Echinoidea.

The *teeth* are narrow and but slightly curved. There is a strong keel on the concave side, and a less conspicuous rounded ridge along the convex side, as in *Echinus*. The cutting edge of the tooth seems not to have been very sharp, but to terminate in a blunt chisel edge rather than in a point. The tooth is, however, a far more effective cutting instrument than the short stumps of the Clypeastroid jaws.

The length of the tooth extracted for examination is 6·2 mm. (measured along the chord), and the breadth from side to side is uniformly ·9 mm.

The relative length of the symphysis as compared with the maxilla in Lovén's specimen was ·74, whereas it is ·67 in the present example. That this proportion increases with the age of the individual seems certain; thus, in a series of measurements I have taken of these lengths in small specimens of *Echinus miliaris*, the proportion varied from ·52 (in a very minute specimen, the total length of the maxilla of which was only 2·3 mm.) to ·61 in a specimen with a maxilla 3·1 mm. long. But the two specimens of *Discoidea* now under comparison have maxillæ of precisely equal length, namely, 8·1 mm., so that the difference in the relative length of the symphyses (·07) is not of necessity due to difference in the age of the individuals. The general proportions of the maxillæ in the new specimen are considerably more slender than those of Lovén's specimen.

The method of articulation with the perignathic girdle is comparable to that of the Clypeastroids. The narrow adoral end of the *fovea magna externa* is deeply depressed, and articulates perfectly with a radial process of the perignathic girdle. Interradially the pyramid seems to have leaned against two somewhat approximated radial auriculæ, and to have had very small possibilities of movement.

As has been previously mentioned, Lovén points out the striking differences between the two types of perignathic girdle in *Discoidea cylindrica*, and assigns the type with prominent auricles to the cylindrical *forma elatior*. His two figures ("Echinologica," pp. 48, 49) exhibit the characters of the girdle in both types very clearly. He shows that the tall form not only has more prominent auricles than the depressed form, but that in it the characteristic interradial ridges that radiate from the peristome to the sides of the test are more strongly pronounced.

The specimen of *D. cylindrica* here described is undoubtedly one of the low or depressed forms. A comparison of the outline in Fig. 1 with that in Wright's monograph of the Cretaceous Echinoids referred to by Lovén (Wright, Pal. Soc., Cret. Ech., 1874, pl. xlvi, fig. 2*a*) shows it to be almost identical in form with that typically depressed specimen. But the characters of the perignathic girdle in my specimen (and also in the companion specimen, which is identical with it in shape and size) conform more or less completely to those ascribed by Lovén to the elevated form. Except for the fact that the auricles are not quite so prominent in the case of the example from Sewell, the drawing in "Echinologica" (p. 49) would serve as a representation of this specimen. This correspondence in the perignathic features of the high and low forms of *D. cylindrica* tends to break down the distinction between them.

It has usually been stated (see Wright, 1874, p. 206) that the hemispherical form of *D. cylindrica* is the young stage of the true cylindrical form, but Lovén suggests that there may be a specific difference between the two forms. The present example seems to me to lessen the probability of the existence of any fundamental distinction between the two forms, and to give confirmation to the older belief. Lovén does not give the sizes of the specimens he describes, so that it is

impossible to judge certainly as to the relative ages of the specimens, but the fact that the auricles in my example are not quite so fully developed as in the original of Lovén's figure on p. 49 seems to indicate that my specimen is the younger of the two. Assuming that the jaws described by Lovén are those of the tall form, then the smaller symphysial proportion in the present specimen lends confirmation to this belief.

Perhaps the most striking feature of the 'lantern' of *D. cylindrica* is its strongly 'regular' character. In many respects the structures closely resemble those in *Cidaris papillata*. The slightly less elevation of the outer faces of the pyramids, the internal keel of the tooth, and the slanting position on the perignathic girdle, are the only obvious differences, save for a slight tendency in the epiphyses of *Cidaris* to converge to form an arch. The epiphyses of *Discoidea* are very like those of the Diademine genus *Asthenosoma*, but in that form again the tooth is grooved on the concave side.

The great similarity between the dental structures in *Discoidea* and the regular Echinoids tends to confirm the belief that the Discoidiidæ are very primitive among irregular Gnathostomata. In the structure of the jaws, at least, these forms might well be regarded as intermediate between the Regularia and the Clypeastrina, for the pyramids bear a strong regular facies, whilst their method of articulation with the perignathic girdle, and the slight modifications that they do present, all seem to tend towards a typical Clypeastrine character.

Summary.—The maxillæ of a specimen of *Discoidea cylindrica* are described, and found to differ somewhat from those described by Lovén in "Echinologica". The epiphyses and teeth of *D. cylindrica* are described for the first time, and are shown to resemble those of several Regular Echinoids.

The differing characters of the perignathic girdle, which were considered by Lovén to be of almost specific importance, are not found to be confined to the different forms of test, and are regarded as differences due to the age of the specimens.

The intermediate character of the family of the Discoidiidæ between Regular and Clypeastrine Echinoids is emphasized.

In conclusion, I wish to express my thanks to Dr. Hoyle, of the Manchester Museum, for permission to develop and describe the specimen; also to Dr. Bather for his help and encouragement, and especially for lending me the proof-sheets of his forthcoming memoir.

LITERATURE REFERRED TO.

1874. T. Wright. Monogr. Brit. Foss. Echinodermata.—Cretaceous: I. Echinoidea; pt. vi, Echinoconidæ, pp. 198–213, pls. xlv–xlvii. (Presence of jaws asserted without proof.)

1886. P. M. Duncan. "On the Perignathic Girdle of the Echinoidea": Journ. Linn. Soc. Zool., vol. xix, pp. 179–212, pls. xxx, xxxi. (Terminology of perignathic girdle.)

1888. Sven Lovén. "On a recent form of the Echinoconidæ": Bihang Kongl. Svenska Vet. Akad. Handl., Bande xiii, Afd. iv, No. x, Stockholm. (Describes one form of girdle in *D. cylindrica*.)

1889. P. M. Duncan & W. P. Sladen. "Note on Perignathic Girdle of *D. cylindrica*": Ann. Mag. Nat. Hist., ser. vi, vol. iii. (Expresses disbelief in the existence of jaws in this genus.)

1890. P. M. Duncan & W. P. Sladen. "On the Anatomy of the Perignathic Girdle of *D. cylindrica*": Journ. Linn. Soc. Zool., vol. xx, p. 48.
1892. Sven Lovén. "Echinologica": Bihang Kongl. Svenska Vet. Akad. Handl., Bande xviii, Afd. iv, No. i, Stockholm. (Describes jaws of *D. cylindrica*.)
1909. F. A. Bather. "The Triassic Echinoderms of Bakony." (Terminology of Echinoid jaws discussed.)

EXPLANATION OF PLATE VI.

Fig. 1.—Side view of the specimen of *Discoidea cylindrica* in Manchester Museum (L. 8806), with the jaw apparatus *in situ*. × 1½.
,, 2.—Outer surface of a pyramid, A in Fig. 1, the two halves separated along the symphysis and the tooth forced between them. As found. × 8.
,, 3.—Inner (inter-pyramidal) view of a pyramid, with the incurved extensions of the halves of the admedian outer plane at the adoral ends. × 8.
,, 4.—Tooth; side view. × 8.
,, 5.—Inner (alveolar) view of a hemi-pyramid, showing the symphysial surface and half the dental slide. × 8.
,, 6.—Epiphysis, inter-pyramidal surface, showing rounded prominence for articulation with a rotula. × 15.
,, 7.—Portion of the perignathic girdle of this specimen, showing the processes. × 3.

III.—On the Composition of 'Borolanite' from Am Meallan, Ross-shire.

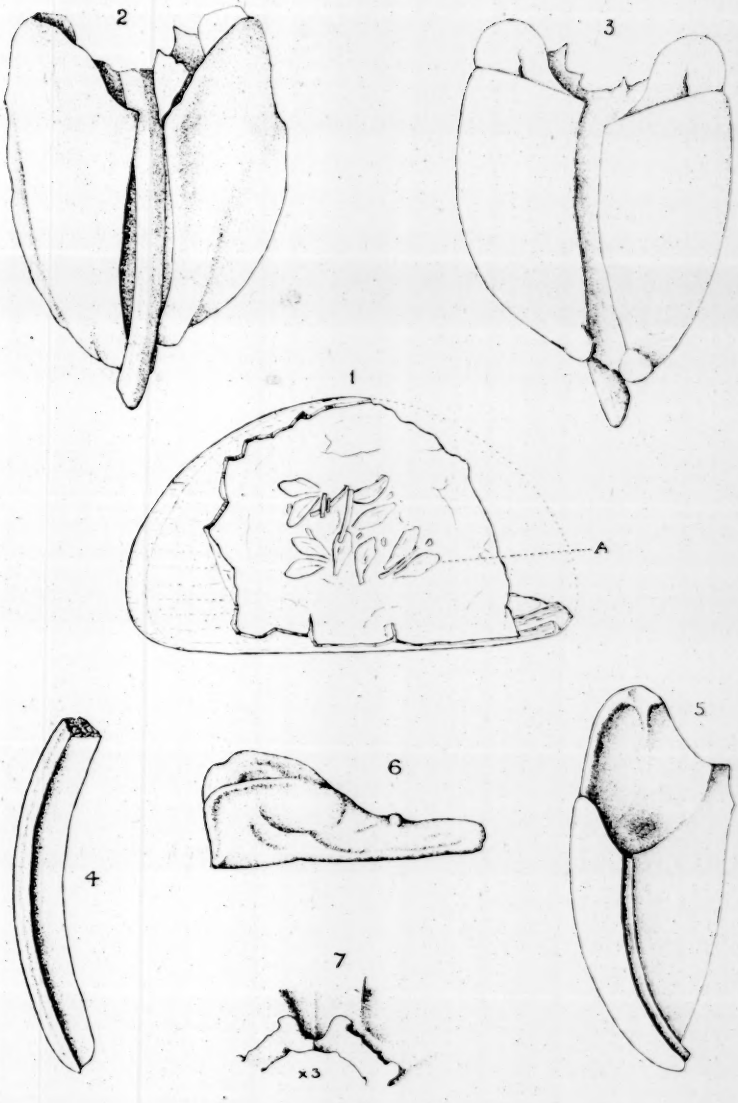
By W. Campbell Smith, Scholar of Corpus Christi College, Cambridge.

THE peculiar garnetiferous rock occurring to the east of Loch Borolan seems to have been first noted by Dr. Callaway in 1883, and is described by Dr. Bonney in an appendix to Dr. Callaway's paper.[1]

The rock was more fully described by Messrs. Horne & Teall in 1892.[2] The authors give it the name borolanite, defining the typical rock as an aggregate of orthoclase and melanite. The mineral composition is described, with special reference to the white patches, which consist of an aggregate of orthoclase and a substance which is probably an alteration product of nepheline or sodalite. The occurrence of a turbid mineral in micropegmatitic intergrowth with the felspar is noted, and it is suggested that this is an alteration product of nepheline. The theory that these white patches are pseudo-leucites was suggested by Professor Derby, who compared them to the pseudo-leucites of certain Brazilian rocks. It is also pointed out that borolanite appears to be a member of the elæolite-syenite family.

An appendix to this paper of Messrs. Horne & Teall records the discovery of much decomposed borolanite in the Eilean Dhu Limestone at Elphin, and of two vertical dykes in the Torridon Sandstone at Camas Eilean Ghlais. The dyke is of medium texture and brownish-grey colour. Hand-specimens show melanite and lath-shaped cleavage faces of felspar. Sections show the rock to be composed of an aggregate of orthoclase, nepheline (partly decomposed to a substance giving aggregate polarization), melanite, ægirine, and biotite. The melanite is either pale yellow or deep brown, a pale zone often surrounding a dark nucleus. Two bulk analyses were made, one by Mr. Hort Player and the other by Dr. Teall; the latter also analyzed the part soluble in hydrochloric acid, thereby proving the presence of nepheline.

[1] Q.J.G.S., 1883, vol. xxxix, p. 409.
[2] Trans. Roy. Soc. Edinburgh, vol. xxxvii, p. 163.



H. L. H. del.

FIGS. 1–7.—Dental apparatus of *Discoidea cylindrica* (Lamk.).

In a later paper[1] Dr. Teall points out the similarity between the rocks of Cnoc-na-Sroine and those of Christiania. He again mentions the dyke-rock as being allied in mode of occurrence and mineral composition to the tinguaites of Rosenbusch, but differing from these in containing 5 per cent. of lime, and also in structure. Accordingly, after much hesitation, he has classed it as borolanite. He also discusses the relations between the rocks of Cnoc-na-Sroine and those of Magnet Cove, Arkansas, and regards borolanite as almost identical with the leucite-syenite of the latter locality. To support this theory he compares the analyses of the dyke-rock with that of the leucite-syenite. The quotation of this analysis in this place seems to have led to its being accepted by Rosenbusch as that of "Borolanit vom See Borolan". The same analysis has also been taken as that of "Borolanite, Borolan, Scotland" by Washington and by Osann in their collections of analyses.

In a paper,[2] "Ueber Borolanit und die Gesteine des Cnoc-na-Sroine Massivs in Nord-Schottland," Dr. J. Shand points out the above-mentioned error. In the part of this paper which deals with borolanite the author distinguishes between the typical rock (as originally defined) and the spotted variety. He has paid most careful attention to the micrographic intergrowth with orthoclase, and to the nature of the zeolite. He considers that the former consists of sodalite or analcime, and applies to the finger-print structure, which it forms with the orthoclase, the term 'dactylotype'. The exact nature of the zeolite is still rather uncertain, and, pending further results, he retains Brögger's term 'Spreustein'.

Hoping to throw light on the 'pseudo-leucite' theory raised by Professor Derby, Dr. Shand analyzed some of the white patches cut from a specimen from Allt a' Mhuilin; he also analyzed some of the black material. The figures obtained were as follows:—

	I.	II.	III.
SiO_2 . . .	44·85	56·26	55·91
TiO_2)			
Al_2O_3) . .	17·10	21·93	23·88
Fe_2O_3 . . .	10·06	·67	3·12
FeO . . .	2·71	—	—
MnO . . .	—		
CaO . . .	14·00	1·46	1·22
MgO . . .	·39		tr.
Na_2O . . .	1·67	4·95	9·55
K_2O . . .	6·92	10·63	6·09
H_2O . . .	1·66	4·16	1·46
	99·36	100·06	101·23

I. Black material without visible pseudo-leucite.
II. Pseudo-leucite.
III. Pseudo-leucite of Serra de Tinga, Brazil.
Analysis III is quoted for the sake of comparison.

[1] Geol. Mag., 1900, Dec. IV, Vol. VII, p. 386.
[2] *Neues Jahrb. f. Min.*, etc., 1906, Beilage Band xxii, p. 413.

In the same paper Dr. Shand gives a sketch-map of the district, and a brief description of the positions of various localities mentioned above may not be irrelevant.

The main mass of rocks occupies about 5 square miles between Ledbeg and Loch Borolan, attaining its greatest height at Cnoc-na-Sroine, east of the former locality. Aultnacallagach is situated on the north-east of Loch Borolan, and the main exposures of borolanite occur in the stream Allt a' Mhuilin, to the south-east of this place. Am Meallan is on the roadside, close to Allt a' Mhuilin and slightly to the north-west. It should also be noted that Camas Eilean Ghlais, where the dyke-rock occurs, is on the coast about 18 miles west of Loch Borolan.

A summary of most of the work above mentioned is given in the Memoir of the Geological Survey of the North-West Highlands.

At the suggestion of Mr. R. H. Rastall an analysis of a borolanite from Am Meallan has been made. The specimen, kindly provided by Mr. Harker and collected by him a few years ago, was dark grey in colour, with numerous ill-defined white patches, which never exceed 1 cm. in diameter. The groundmass was fine-grained, the garnets being very small. Some lath-shaped cleavage faces of felspar were observable.

To obtain a good average sample about 400 gms. of rock was coarsely powdered and well mixed; about 100 gms. of this was then more finely powdered, and finally about 10 gms. ground down for analysis. Silica and the bases were estimated on about 1 gm. of substance, alkalies and ferrous iron being each estimated on a separate quantity of about ·5 gm. Water was determined on about 1 gm. of powder, contained in a platinum boat and heated in a quartz tube, first by a Téclu burner and finally by a strong blast. The water was collected in a weighed sulphuric acid tube. The loss in weight of the boat was in each case slightly less than the weight of water collected, owing to the presence of Fe O. For the rest the directions of Washington and Hillebrand were followed throughout. The results were as follows:—

	I.	II.	III.	Mean.
SiO_2	48·27	48·12	—	48·19
TiO_2	1·85	1·66	—	1·75
Al_2O_3	18·52	18·52	—	18·52
Fe_2O_3	4·57	4·45	—	4·51
Fe O	1·64	1·73	1·68	1·68
Ca O	10·23	10·35	—	10·29
Mg O	1·18	1·07	—	1·12
Na_2O	3·43	3·46	—	3·44
K_2O	8·13	7·98	—	8·05
H_2O (above 105°)	2·99	3·01	—	3·00
H_2O (105°)	·45	·45	—	·45
	101·26	100·80	—	101·00

Sp. gr. = 2·77.

Traces of P_2O_5 and Mn O were also present.

Three sections were cut from the remains of the specimen analyzed, and these were examined with a view to getting some idea of the proportions of minerals present.

The garnets are quite typical, pale brown, and filled with inclusions of small sphenes, some biotite and a very little apatite. The larger crystals (2 mm. diam.) are very irregular and broken; the smaller (·1 mm. diam.) show excellent sections of rhombic dodecahedra. No sphene occurs outside the garnets; apatite is sparingly present, and green pleochroic ægirine was observed only as two small patches in one section. The biotite is dark green, occurring as somewhat ragged flakes in the orthoclase-melanite aggregate and to a small extent as inclusions in the garnet.

'Daetylotype' structure was well shown, the material forming it being apparently of *lower* refractive index than orthoclase. Here and there rather indefinite black crosses, shown by parts of the zeolite between crossed nicols, were observed.

Estimates of the volume-percentages of the minerals of each of the three slices were made by three independent observers, making nine in all. The mean of the nine is: Garnet, 25·3; orthoclase, 51; 'Spreustein,' 19; and biotite, 5. Taking the specific gravities of these minerals as 3·6, 2·57, 2·3, and 2·9 respectively, the percentage mineral composition becomes: Garnet (including sphene), 32·48; orthoclase, 46·75; 'Spreustein,' 15·59; and biotite, 5·17.

The specific gravity calculated from these values, assuming the minerals to have the specific gravity above given, is 2·79. The actual specific gravity was found to be 2·77.

In view of the fact that the only minerals present, whose composition is known, are orthoclase and sphene, and further that there is very little guide as to the composition of the zeolite, any definite calculation of mineral composition from the analysis is extremely difficult, and it is probable that several equally plausible arrangements might be made. The figures which seem to fit best are here given:—

	Ratios.	Melanite.	Sphene.	Thomsonite.	Biotite.	Orthoclase.
SiO_2 . .	·803	·164	·022	·133	·049	·433
TiO_2 . .	·022	—	·022	—	—	—
Al_2O_3 . .	·181	·027	—	·066	·016	·072
Fe_2O_3 . .	·028	·028	—	—	—	—
FeO . .	·023	·018	—	—	·005	—
MgO . .	·028	·008	—	—	·020	—
CaO . .	·184	·143	·022	·011	·008	—
Na_2O . .	·055	—	—	·055	—	—
K_2O . .	·086	—	—	—	·016	·070
H_2O . .	·166	—	—	·166	—	—
		26·66	4·51	21·66	7·74	38·92
Calculated . .		30·97		21·66	7·74	38·92—99·27
Estimated . .		32·48		15·59	5·17	46·75—99·99

A fair degree of approximation is observed between the calculated and estimated results.

The melanite is assumed to contain all the Fe_2O_3, and to have the composition of a melanite from the nepheline-syenite of Dungannon, Ontario (after depriving it of sphene and water). A thomsonite is selected because it is the only zeolite which will bring about the proper ratio between $Na_2O + CaO$, and water. In view, however, of the rather uncertain condition of the water in zeolites, this cannot be regarded as a strong piece of evidence that the zeolite has this composition. The biotite is purely hypothetical, and doubtless should contain some water.

The dyke-rock of Camas Eilean Ghlais seems to have very little in common with borolanite. A rough calculation of the 'mode' shows it to contain about 20 per cent. of nepheline, 15·5 per cent. melanite, 42 per cent. orthoclase, with some ægirine, nosean, and biotite. A glance at the two analyses given below shows the great difference between the two rocks—

	Am Meallan.	Camas Eilean Ghlais.
SiO_2	48·19	47·8
TiO_2	1·75	·7
Al_2O_3	18·52	20·1
Fe_2O_3	4·51	6·7
FeO	1·68	·8
MnO	tr.	·5
MgO	1·19	1·1
CaO	10·29	5·4
Na_2O	3·44	5·5
K_2O	8·05	7·1
H_2O (above 105°)	3·00	2·4
H_2O (105°)	·45	
BaO	—	·8
SO_3	—	·4
	101·00	99·3

It seems very difficult to find any rock whose composition is very near that of borolanite.

A calculation of its true position in the quantitative classification of Cross, Iddings, Washington, and Pirsson shows that it falls in Subrang 3, Rang 2 (Vulturase), Order 7 of Class II. No other analyses seem to fall in this subrang. The dyke-rock falls in a similar position in Order 6 of the same class, and therefore is in a sense nearly allied to borolanite. The 'norm' of borolanite shows very little similarity to the 'mode' or true mineral composition, orthoclase being the only mineral which occurs in both. The 'norm' is as follows: orthoclase, 30·86 per cent.; anorthite, 11·12; leucite, 13·32; nepheline, 15·62; wollastonite, 16·70.

Taking the molecular ratios of SiO_2 and alkalies as abscissæ and ordinates respectively, about a hundred analyses, mainly of plutonic rocks, were plotted on squared paper. The points fall roughly into the two well-known curves 'alkaline' and 'calc-alkaline', and it was hoped that the rocks closely allied to borolanite might be thus found. The result is somewhat disappointing. Borolanite falls on the upper curve, and occupies a position intermediate between the nepheline and

leucite syenites on the one hand and the essexite group on the other. In this position it stands rather alone, its three nearest neighbours being ijolite from Umptek and augite-syenites from Hedrum (Norway) and from Yogo Peak.

The dyke-rock falls nearest to an ijolite from Iiwaara (Finland), leucite-syenite from Shonkin Creek, and amphibole-malignite from Poobah Lake, Canada.

Borolanite is more acid and more alkaline than either the nepheline-syenite, leucite-syenite, or leucite-tinguaite-porphyry of Magnet Cove.

With reference to the Christiania rocks, the alkali and silica ratios of borolanite are about half-way between those of laurdalite and the essexite of Sölvsberg. Its alkali ratio is nearly identical with that of laurvikite from Tönsberg.

In a recent paper[1] Dr. F. H. Hatch has published a new scheme of classification for the plutonic rocks. In this the basic rocks are divided into the alkali-gabbro and gabbro families; the alkali-gabbros are further divided into nepheline-gabbro, essexite, shonkinite, and kentallenite sub-families. The rock of Camas Eilean Ghlais falls in the nepheline-gabbro sub-family along with theralite and covite. Borolanite itself appears to fall in the shonkinite sub-family, as it undoubtedly belongs to the potash series. By plotting the 'rock-pictures' by Brögger's modification of Michel-Lévy's method it can readily be seen that borolanite bears affinities to the shonkinite of Poobah Lake, and also that it belongs to the same series as plauenite (potash-syenite of Plauen, Dresden).

An isolated analysis of one specimen from such an interesting locality is of very little use in determining the affinities of the rock, and it is hoped that further analyses of the Cnoc-na-Sroine complex will be made, so that it may be possible to compare these rocks with those of Magnet Cove and Christiania, and to arrive at some definite conclusions as to the origin of borolanite.

In conclusion, I have to acknowledge my great indebtedness to Mr. Rastall for his very valuable assistance, and also to Dr. Shand for useful information and suggestions. The analysis was made in the Mineralogical Laboratory at Cambridge, and I have to thank Dr. A. Hutchinson for his assistance and advice in this part of the work.

IV.—Coal Pebble in a Coal-seam.

By W. S. Gresley, Assoc. M. Inst. C. E., F.G.S.

Recorded Coal Pebbles.

Logan, in 1840, noted the occurrence of pebbles of cannel in the roof of a coal-bed in South Wales; also of pebbles of coal in the 'Pennant' rock (Proc. Geol. Soc., vol. iii, p. 276). De la Beche refers to coal pebbles in the Monmouth and Glamorganshire Coalfield,[2] and H. K. Jordan to similar forms of coal in the

[1] *Science Progress*, No. 10, October, 1908.

[2] [Mem. Geol. Survey, 1846, vol. i, pp. 159, 193, etc.; see also *Geology of the S. Wales Coal-field*, 1907, pt. vii, by A. Strahan and others.—Ed.]

base of the Pennant Series, and to a coal pebble the size of a hen's egg in the roof of the 'Rock Fawr' coal-seam near Bridgend (Q.J.G.S., vol. xxxiii, p. 932).[1] In the roof of the 'Nanaimo' coal, in Vancouver Island, a coal pebble in a conglomerate was recorded in 1906. Several instances of water-worn lumps of coal have been mentioned in the volumes of the second Geological Survey of Pennsylvania as having been found in the semi-bituminous and Pittsburg regions.

Pebble of Coal in Coal.

Having collected all available notices of rolled pebbles and of angular or travelled rock-fragments discovered *in* seams of coal, or in the floors and roofs of coal-beds, as well as in the Coal-measures generally, for a period of twenty-five years, the writer has just met with the only instance known to him of the occurrence of a rounded fragment of *coal* actually embedded in a seam of coal. If this specimen does happen to be unique, the circumstances of its occurrence need create no wonderment, since rounded fragments of almost every *other Coal-measure rock* would seem to have turned up either actually in or near to seams of coal in one coalfield or another.

Location, etc., of the Coal Pebble.

Found, lying flat, in about the middle of the 'Little Coal' seam, in the Donisthorpe Colliery, in Overseal, Derbyshire, in the Leicestershire and South Derbyshire Coalfield, and at a depth of about 900 feet. The seam is about 4 ft. 10 in. in height, and is believed to lie at about the middle of the Middle Coal-measures.[2] The character of the seam is what may be called ordinary house-coal, but the lower half of it is, on the whole, much harder or more 'spirey' than is the upper portion, which, for the most part, is 'dicey' or soft. Now, it was just within the bottom of the dicey layers that this coal pebble was discovered, the discovery being made in this way: A workman on the 'screens' at the surface, in order to separate an ordinary lump composed of part soft and part hard coal, split the same with a pick and thus exposed the pebble. The specimen was handed to the foreman, who presented it to the writer a few days afterwards.

Parenthetically it may be stated that a few years ago the Manager of this colliery (Mr. J. Armson) gave the writer a well-rounded pebble of pale-brown, fine-grained quartzite, which had been found in the clay floor of this same 'Little Coal' at this same colliery; also that, some thirty-five years ago now, a much larger quartzite boulder occurred in the same horizon (in the underclay) at a colliery about 3 miles north of Donisthorpe. For a description of this, as well as of other smaller erratics in these Coal-measures, see the author's paper on "The occurrence of Boulders and Pebbles in the Coal-measures" (Trans. Manchester Geol. Soc., 1888).

[1] [See also remarks by W. Sanders and H. Cossham on pebbles of coal in the Bristol Coalfield. The pebbles found in the Upper Measures were stated to be anthracitic, proving their derivation from the Lower Measures. (Geol. Mag., 1865, p. 134.)—Ed.]

[2] There are, approximately, 1,000 feet of Coal-measures above and 1,000 feet beneath this seam.

Description of the Pebble.

Fairly well-rounded, but bearing decided traces of vertical joints belonging to the layer or bed from which it was doubtless derived. In form flattish subangular, being rather suggestive of a flattened pear. The grain or laminæ of the material lie parallel with the flatter sides. Thickness about $1\frac{3}{4}$ inch, but quite uneven; not unlikely the thickness of the pebble approximates that of the individual band from which it was derived. Longer diameter $3\frac{1}{2}$ inches; maximum width about 2 inches. The surface all over may be described as rough and uneven, considerably pitted, and quite concave on part of one of its vertical sides, the rest being very convex. The roughness of surface is about similar to that of a Brazil nut. The pittings, etc., upon the horizontal or flatter parallel surfaces are mainly due to the wearing away of little patches of fossil charcoal. A few shallow and parallel striæ run approximately parallel with the longest diameter, and occur mainly on one flat side only. They are just such scratches that a fragment of coarsish sandstone makes when rubbed across similar coal. The material is very hard, compact, dull, heavy coal, and contains, besides numerous wee specks, streaks or shred-like bits of lustrous hydrocarbonaceous materials, very many macrospores or spore cases measuring about $\frac{1}{30}$ inch across. These fossils show up quite conspicuously on the pebble's surface.[1] In short, the coal is not at all unlike that of some of the spirey layers belonging to the 'Main Coal' seam of the same field, nor of similar hard layers found in the 'Roaster' coal some 10 miles to the east, and in the 'Slate' seam near Nuneaton, in Warwickshire, 15 miles distant. It is extremely probable that the matrix of this pebble consists mainly of spores, because Mr. Edward Wethered, F.G.S., found that a micro-slide of coal, to all appearance, so far as the author can see, resembling this, was so composed. The pebble weighs about $2\frac{1}{2}$ oz.

History of the Pebble.

From its position in the coal-seam the best explanation is that it got there by flotation, in all probability was dropped from the roots of a tree, in which it had become entangled in some way, floating in water over the site. Thus the inference is that this seam of coal was deposited below water. The pebble, to become such as described, has presumably travelled a considerable distance—has, at all events, been swirled about in water, and by attrition and pressure with rock débris become worn down to its present shape and size. Now, such subjection to rough treatment must of course have taken place before it got into the soil, or, say, *pebbly deposit*, in which the tree-ferns, etc., would seem to have grown. This 'soil', in part at any rate, was formed of Coal-measure débris, so that Coal-measures actually containing perfectly formed coal must have been elevated and undergoing denudation at this very time, i.e. shortly before the forming of the Little Coal seam. Granting this, it is evident that the coal-bed containing the spirey layer of which our pebble is a part was an older seam than the Little Coal. There is no evidence that I know of in the present coalfield that

[1] The pebble takes a high polish similar to spirey coal.

upheaval and denudation of coal-beds were going on *pari passu* with the deposition of the workable coals, a condition of things required, as it seems to me, to account for this coal pebble.

Perhaps the most interesting and instructive point in the story of this coal pebble lies in the fact that whilst the central seams of coal of the Middle Coal-measures were being laid down in a quietly subsiding bay or flat, underlying or older beds of completely formed coal, etc., not so very far away, were, by the waves, being reduced to mud, sand, and gravel, on flats composed of which grew trees, etc., at about sea-level.

Lithology.

Now, this is *not* a water-worn or rounded *piece of wood or fragment of a tree*, but a *bonâ-fide pebble* of that puzzling compound we know as coal *in* coal. It furnishes still another instance of what has always to the author been a conundrum, a seeming paradox in lithology, which is this: How is it that pebbles or fragments of rocks in the shape of inclusions or individual bits composing a conglomeratic or brecciated mass enclosed in a stratum of normal rock, are, to all appearances, not dissimilar from the enclosing bed in its normal or undisturbed condition? e.g., you get pebbles and fragments of Carboniferous Limestone in the shape of a conglomerate in what to all outward appearances seems to be a normal stratum—iron-ore fragments in iron-ore beds; bits of slate in a slaty massif; rounded sandstone in sandstone beds, and so on—in short, rocks calcareous, arenaceous, siliceous, argillaceous, carbonaceous, etc. The question that puzzles me is, *why is not now the coal pebble* of ordinary coal, in a seam of the same, *farther advanced towards a condition of anthracite*, since it must have been exposed for vast ages to *further mineralizing influences* since burial—its *second burial*—in the seam? And it is just as hard to explain why or how the substance of such a pebble had arrived at maturity as to its condition *as coal* during the Middle Coal-measure period, for the very aspect and nature of the pebble speaks for itself; it was just as much coal *then* as it is to-day, apparently neither more nor less so! That is just where the *inexplicable* seems to come in! 'Inclusions' *seem* to have been incapable of receiving further metamorphism on becoming inclusions. The facts seem to point to solidification of sediments, coupled with hardening, shrinkage, jointing, and other rock-forming processes as having operated to the completion of the *normal* stage—the strata as we now have them—*very rapidly indeed* after burial. Is not this a phase of our science not yet much understood, and certainly a difficult but most interesting problem for observers to help solve?

V.—The Probable Source of the Limestone Pebbles in the Bunter Conglomerate of West Somerset.

By Edgar C. Martin, B.Sc., A.I.C.

(WITH A MAP.)

WHEN the Budleigh Salterton Pebble-bed is traced northward into Somerset it loses its unconsolidated character and passes into a calcareous conglomerate. The change takes place north of Burlescombe, and is complete at Thorne St. Margaret; thence to

Combe Florey this division of the New Red Sandstone Series is generally represented by a conglomerate composed of pebbles of limestone, quartz, and grit, more massive in its lower part.[1] For some distance north of Combe Florey the upper beds of the division are faulted out and the lower beds are represented by a loose, rubbly gravel of subangular fragments of Devonian grit in an earthy or sandy matrix. The conglomerate reappears at Vellow, near Stogumber, and is found in several places in the Williton district, whilst in other places it is represented by gravels, sands, and sandstones.

The influx of limestone and grit pebbles which takes place north of Burlescombe has usually been referred to the degradation of the Culm limestones and Devonian rocks.[2] The study of the distribution of the minerals in the matrix of the Pebble-bed and conglomerate between Budleigh Salterton and Milverton lent support to this view, and led Mr. H. H. Thomas to deduce the existence in the Bunter period of a main sediment-bearing current from the south, joined by a minor current from the west in the neighbourhood of Burlescombe.[3] It is difficult to believe, however, that the large quantity of limestone in the conglomerate between Thorne St. Margaret and Combe Florey has all been derived from the comparatively small inliers of Culm limestones near Burlescombe, or from the thin and impersistent limestones occurring to the west of the district, especially in view of the fact that the Culm inliers are surrounded by Lower New Red deposits, and they cannot, therefore, have occupied a larger area in Bunter times than they do now.

In the case of the massive conglomerates of the Williton district the difficulty of referring the limestone pebbles contained in them to the Devonian rocks of the surrounding area seems to have been felt by De la Beche, who suggested that "compact grey limestones probably occur beneath the red sandstone series near Sampford Brett and Stogumber, for red conglomerates there worked for lime abound in rounded stones and pebbles of a grey compact limestone".[4]

The Carboniferous Limestone to the north and north-east appears to be a much more probable source for the limestone pebbles in the conglomerate. Neglecting the Cannington Park inlier, which lies on the east side of the Quantock Hills, the nearest exposure of Carboniferous Limestone is about 15 miles north-east of Williton, or no further than the Culm limestones on the south. In the south of Glamorgan Keuper, Rhætic, and Liassic deposits successively overlap one another and rest directly on the Carboniferous Limestone, each of the newer deposits assuming a peculiar 'littoral' facies in the vicinity of the older rock.[5] During the Bunter period South Glamorgan was evidently a land area formed chiefly of Carboniferous

[1] Memoirs of the Geological Survey: "Geology of the Quantock Hills, etc.," 1908, p. 46.

[2] Ibid.: "Geology of the Country between Wellington and Chard," 1906, p. 14.

[3] H. H. Thomas, B.A., F.G.S., "The Mineralogical Constitution of the Finer Material of the Bunter Pebble-bed in the West of England": Q.J.G.S., 1902, pp. 620–32.

[4] *Report on the Geology of Cornwall, Devon, and West Somerset*, 1839, p. 55.

[5] Memoirs of the Geological Survey: "The Geology of the Country around Bridgend," 1904, ch. v.

Limestone and probably joined to the Mendip Hills by limestone ridges, of which fragments still remain in the islands in the Bristol Channel.

In June, 1907, in a small conglomerate quarry at the south end of Langford Heathfield, I noticed several limestone pebbles with Corals and Brachiopods, which suggested Carboniferous Limestone of Mendip type rather than the Culm limestone. During two recent visits to Wiveliscombe I was able to collect fossiliferous pebbles from several localities between Thorne St. Margaret and Williton. In the following notes I have briefly described the fossils obtained (the localities being taken from south to north) and have then discussed their bearing on the origin of the conglomerate.

Description of the Fossiliferous Pebbles.

Thorne St. Margaret. — Several more or less silicified limestone pebbles with crinoid fragments and badly preserved Brachiopods were found in an old quarry north of the church by the road to Kittisford.

Langford Heathfield.—In the small quarry at the south end of the Heathfield I found a large limestone pebble with *Syringopora* (closely resembling *S. ramulosa*, Goldfuss). Another pebble of very hard limestone showed Spiriferids on the weathered surface.

Cobhay.—Fossiliferous limestone pebbles, with crinoid fragments, Spiriferids, etc., are common in an old quarry south of Cobhay Farm, near Bathealton, but the limestone is so hard that the fossils cannot be extracted, and it is only on the weathered surfaces that the fossiliferous nature of the stone becomes apparent. Amongst the fragments in this quarry I found a beautifully weathered out piece of silicified limestone with small crinoid fragments and Bryozoa (Fenestellids and *Rhabdomeson* or *Rhombopora*); its appearance strongly suggested some of the beds in the Lower Carboniferous Limestone of the Bristol area.

Owing to a fault the Bunter Conglomerate at Cobhay is brought close to the Lower Breccio-Conglomerate subdivision, which can be examined in a small quarry east of the farm. In both divisions the limestone pebbles are fairly well rounded and bear a general resemblance to one another, but are usually much smaller in the lower division.

Milverton.—In the large quarry north of Milverton railway station I found two pebbles of hard, unaltered limestone, showing sections of *Zaphrentis*. About a mile further north, in a quarry east of the road to Halse, a slightly silicified limestone pebble with a portion of a large *Productus* was found.

Wiveliscombe. — In Castle and Tipnoller Quarries, north-east of Wiveliscombe, fossiliferous limestone pebbles, more or less silicified, are common. In some cases the silicification has only extended to the fossils, which can be extracted in a more or less fragmentary condition by dissolving out the matrix with dilute hydrochloric acid. In these pebbles I found circular and pentagonal crinoid sections, Brachiopods (Spiriferids, cf. *Chonetes Hardrensis*, etc.), and a Gasteropod resembling *Capulus*. In other cases the whole pebble is silicified; one of these contained crinoid fragments and Bryozoa (*Fenestella*, *Rhabdomeson*?).

Williton District.—In massive conglomerate, with large limestone and grit pebbles, exposed in the face of an old quarry at Vellow, near Stogumber, I noticed several unaltered limestone pebbles with *Zaphrentis* and other fossils on the weathered surface. Owing to the

Sketch-map showing the probable directions of the sediment-bearing currents in Bunter times.

hardness of the stone I was unable to extract either the pebbles or the fossils. Further north, in the large quarry on the north side of the railway at Woolston, I found several large pebbles of very hard grey limestone with Brachiopods (*Productus* and Spiriferids) and crinoid fragments.

Source of the Limestone Pebbles.

Although the fossils in the limestone pebbles do not appear to admit of exact determination, the evidence seems quite sufficient to justify the conclusion that they have been derived from Carboniferous Limestone of the Mendip or Avonian type. A few of the normal Carboniferous fossils (including Spirifers and a doubtful *Zaphrentis*) occur in the Culm limestones, but they appear to be rare exceptions,[1] whilst the usual fossils are Posidonomyæ and Goniatites, which, in the neighbourhood of Burlescombe, are much more common in the shales than in the limestone. But, on the whole, fossils, with the exception of crinoid fragments, are very rare in the Culm limestones; on the other hand, there is abundant evidence that some, at least, of the limestone in the conglomerate has been derived from a very fossiliferous rock. The difficulty of getting good specimens of the fossils is due, not to their scarcity, but to the hardness of the stone and the coating of oxide of iron which so often covers the pebbles.

The Carboniferous Limestone of South Wales contains fossils similar to those found in the conglomerate, and often silicified; moreover, a large area of this limestone was exposed to the north and north-east whilst the conglomerate was being formed. It is from this area that some, at least, of the limestone pebbles found in the conglomerate appear to have been derived.

The origin of the Bunter Pebble-beds of Budleigh Salterton and the Midland Counties has been discussed in numerous papers in the Geological Magazine and elsewhere,[2] and the view that these deposits are of fluviatile origin now appears to meet with very general acceptance. In the case of the Budleigh Salterton Bed the 'foreign' quartzite pebbles have been traced to the old Armorican land lying to the south or south-west. To the north of Budleigh Salterton the pebbles decrease in size, and Mr. H. H. Thomas has found that the percentage of heavy minerals in the matrix of the Pebble-bed falls from 75 per cent. at Budleigh Salterton to 71 per cent. at Uffculme. There is thus good evidence for the theory that the Budleigh Salterton Bed was formed by a large river from the south or south-west. In the neighbourhood of Burlescombe this river appears to have received an important tributary from the north, flowing down the valley between the Quantock and the Brendon Hills and bringing with it pebbles of Carboniferous Limestone. The united stream probably found an outlet to the east.

On the accompanying sketch-map are shown the probable directions of the sediment-bearing currents in East Devon and West Somerset during the Bunter period. The river from the north probably received tributaries from the Devonian areas on both sides of its valley; to these streams, which would have had a short but rapid course, are to be attributed the rubbly gravels of little-worn Devonian grit fragments, found between Yellow and Combe Florey, and the

[1] Rev. W. Downes, B.A., F.G.S., Transactions of the Devonshire Association, 1878–9.

[2] A useful summary and discussion of these papers is given by O. A. Shrubsole, F.G.S., in a paper "On the Probable Source of some of the Pebbles in the Triassic Pebble-beds of South Devon and of the Midland Counties": Q.J.G.S., 1903, p. 311.

similar deposits of the Williton district. The southern river was probably joined by tributaries from the west, as suggested by Mr. H. H. Thomas.

Note on the Breccio-Conglomerate.

The lowest division of the New Red Series, when traced from Devon into Somerset, undergoes a change similar to that which takes place in the Bunter division. The gravels of the Tiverton district are represented in West Somerset, partly by similar deposits and partly by a breccio-conglomerate of subangular or rounded fragments of limestone, grit, quartz, and slate. I found limestone pebbles with crinoid fragments near Escott, at Bathealton, and at Cobhay; but, in the absence of other fossils, there is not enough evidence to determine whether these pebbles represent Devonian, Culm, or normal Carboniferous Limestones: they most resemble the latter.

The fossiliferous nature of the limestone pebbles occurring in the Breccio-Conglomerate is mentioned in several places in the recently published Memoirs of the Geological Survey, and corals are stated to occur in the limestone pebbles near Escott,[1] but no species are mentioned. At Langley, near Wiveliscombe, "the limestone fragments are numerous, and mostly grey or pale grey, and sometimes oolitic; the majority resemble Carboniferous Limestone (Mendip type) rather than Devonian."[2]

In a recent paper[3] I pointed out that fragments of grit with Upper Devonian fossils can be traced in the Lower New Red gravels for a distance of 15 miles southward from the outcrop of the Upper Devonian rocks. Although it is possible that some of these fossiliferous fragments may have been derived from Upper Devonian rocks concealed beneath the New Red deposits in the Tiverton and Crediton Valleys, as suggested by Etheridge,[4] it is more probable that they have been derived from the north-east. I have not been able to detect similar fragments in the Lower New Red deposits of West Somerset, and this fact is suggestive of drifts from the north or north-east in the case of these deposits as well as in the case of the Tiverton gravels.

If this view is correct, we should expect to find the Culm limestones largely represented in the Breccio-Conglomerate of Sampford Peverell (which lies south-west of the Culm inliers near Burlescombe) and Carboniferous Limestone of the normal or Mendip type in the Breccio-Conglomerate further north. The limestone fragments in the Sampford Peverell Quarries have been referred to the Culm limestones by geologists from De la Beche onwards, and although in a short visit to these quarries I was unable to find any fossiliferous fragments which would have afforded definite evidence of their origin, there seems no reason to doubt that the limestone pebbles have been derived from the Culm limestones, which they closely resemble. Close search in the Sampford Peverell Quarries would probably reveal fragments of shale with *Posidonomya* or Goniatites.

[1] "Geology of the Quantock Hills, etc.," p. 42.

[2] Ibid., p. 43.

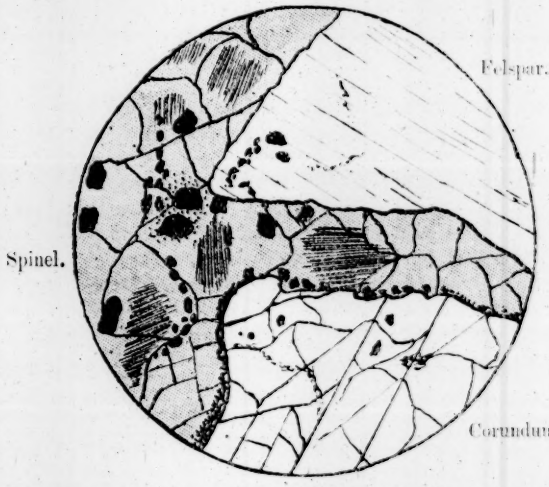
[3] Geol. Mag., 1908, pp. 150–7.

[4] See Mr. W. A. E. Ussher's paper on "The British Culm Measures": Proc. Somersetshire Arch. and Nat. Hist. Soc., 1892.

VI.—Note on an Occurrence of Corundum in Rhodesia.

By F. P. Mennell, F.G.S.

CORUNDUM is one of those rather exceptional rock-formers whose mode of origin is not fully explained, and it is, accordingly, of interest to put on record any new localities for the mineral, together with the features they present. Fragments of it have frequently been found among the old gravels of the Limpopo River, along the Transvaal-Rhodesian and Transvaal-Bechuanaland border, but although the Transvaal Geological Survey has described an occurrence in the Pietersburg district, the source of these fragments for some time remained unknown. However, last year I received from the Rhodesian side of the border, close to Rhodes' Drift on the Limpopo, and northward from the well-known Messina copper-mine, some rocks which included large pieces of a type rich in corundum. The area is known to comprise gneissose granulites, consisting of the contact zone and marginal modifications of a granite mass, and the specimens received included large cleavage fragments of felspar and pieces of coarse granite.



Microscopic section of corundum-bearing rock. × 25 diam.

The corundum occurs in the form of irregular masses of a dull pinkish or greyish colour, up to several inches across. These show the usual well-marked rhombohedral parting, and are sometimes single crystals and sometimes aggregates. The rock in which they are embedded is a felspathic one, to which sparsely distributed hornblende crystals give a somewhat gneissic aspect. Completely encircling each mass of corundum, as if protecting it from the invasion of the felspathic matrix, is a coating of what to the unaided eye looks like magnetite. This sends out straggly offshoots among the surrounding felspar grains, but is only seen near the corundum. The general aspect of the rock is very much that of an augen-gneiss, with the corundum forming the 'eyes'.

Under the microscope the matrix is seen to consist of a coarse-grained aggregate of a much twinned felspar, at least as basic as labradorite. There is a little pale-green hornblende scattered through it irregularly. The corundum is quite colourless, shows a very rough surface, and has many irregular cracks besides the well-defined parallel partings. It is traversed by occasional veins of a brightly polarizing alteration product (? diaspore). Round the corundum is the dark substance noticed in the hand-specimen. This proves to be principally a deep-green spinel, no doubt *pleonaste*, in granular aggregates, associated with a good deal of magnetite. The grains are perfectly isotropic, and have no definite shape even where in contact with the felspar, but there are indications of rectangular cleavage traces, and in some cases the granules are darkened by close-set parallel striations like those sometimes observed in augite.

It is difficult, without having made an examination of the locality, to offer any useful suggestions regarding the origin of this interesting association of minerals.

VII.—A Note on *Phacops* (*Trimerocephalus*) *lævis* (Münst.).

By Ivor Thomas, Ph.D., B.Sc., F.G.S.[1]

THE British form recognized under this designation appears to have been first recorded and figured from this country by J. de C. Sowerby (16, pl. lvii, fig. 30), who named it *Asaphus* or *Trinucleus* (?). He remarks "that no trace of the position of the eyes remains on the cast, which is also the case with the genus *Trinucleus*, Murchison". This form was afterwards allocated by Salter to *Phacops* (*Trimerocephalus*) *lævis* (Münst.) (13, p. 16, pl. i, figs. 5–7; 14, p. 1, pl. ix, figs. 1–5). Phillips had previously named the same species *Calymene lævis*, Münst. (8, p. 129, pl. lv, fig. 250), a determination which both Salter (13, p. 16) and M'Coy (6, p. 404) showed to be at fault. This was complicated by the fact that Münster (7, pl. x, fig. 6; 7*a*, pl. v, fig. 4) had described two different forms under the same specific name, *Trinucleus? lævis*, and *Calymene lævis*, the latter of which Salter (13, p. 18) correctly adjudged to be a synonym of *Phacops granulatus* (Münst.) (*Calymene* auct.) (7*a*, pl. v, fig. 3). M'Coy had previously noted the identity of *C. lævis* Münst., with *Calymene granulata* of the same author, but assigned it to his genus *Portlockia* (6, p. 404).

Münster's figure of *T. ? lævis*, which gave the specific name to *Ph.* (*Trimerocephalus*) *lævis* of Salter, is very poor, and a determination by comparison with it would appear at present to be quite unsafe. A similarity certainly exists between the two forms in the absence of eyes and in the smooth character of the surface. But distinctions exist; for instance, among other details, the ratio of the length of the head-shield to its width is considerably less in Münster's figure than in the British form, while the broad marginal border seems

[1] Communicated by permission of the Director of the Geological Survey.

much more accentuated in the former than in the latter. The question is still further complicated by the fact that Gümbel (4, p. 495, pl. A, figs. 7–9) refigures what he expressly states is the original of *T.*? *lævis*, Münst. His figure shows the presence of well-marked eyes, together with granules over the surface of the head-shield. Other differences are easily recognizable on comparison of the two figures. Gümbel identifies the form with *Ph. cryptophthalmus*, Emmr. (2, pp. 27, 40, 61), which name he retains in preference to *lævis*, at the same time deprecating Salter's retention of the latter name. Salter, however, had expressed an opinion in two of his works (13, p. 16; 14, p. 1) that it might be found necessary to give the British form another specific name. In the later work (14, p. 1) he even suggests the use, should occasion arise, of *trinucleus* as a substitute for *lævis*.

As no traces of eyes have been noticed on any of the numerous specimens of the so-called *Ph.* (*Trimerocephalus*) *lævis* found in this country, there is strong reason to believe that eyes were never present. In this character the species would be more allied to *Ph.* (*Trim.*) *anophthalmus*, Frech (3, p. 270), and *Phacops cæcus*, Gürich (5, p. 362, pl. xv, fig. 4), in which eyes are likewise absent, than to *Ph. cryptophthalmus*, Emmr. Compared with *Ph.* (*Trim.*) *anophthalmus*, Frech, the angle made by the dorsal furrows bounding the glabella of the British form is considerably larger, the marginal border is narrower, the ratio of the length of the glabella to its width is much less, while the frontal margin of the glabella is more curved.

Compared with *Ph. cæcus*, Gürich, the head region of the British form is considerably wider in proportion to the length, and the frontal margin of the glabella is less acute. The glabella and cheeks of the Polish specimens are covered with granules, while various other differences of detail also help to distinguish the two forms. Other examples of *Trimerocephalus* without eyes have been described by various authors, but none appears to agree with the British species.

If satisfactory traces of eyes could be found in the numerous specimens from Cornwall and Devon, the form might probably be allocated near to *Ph.* (*Trim.*) *cryptophthalmus*, Emmr., as interpreted by Gümbel's figure, which is unfortunately unaccompanied by a description. *Ph.* (*Trim.*) *cryptophthalmus*, however, furnishes another instance of a confusion arising through different interpretations by different authors. Thus *Ph. cryptophthalmus*, Richter (9, p. 20, figs. 23–31), belongs, according to a later work of the same author (10, p. 116), to *Ph. granulatus* (Münst.), while a new *Ph. cryptophthalmus* of the same work (10, pl. ii, figs. 1–5) probably belongs to *Ph. brevissimus*, Drevermann (1, p. 115, pl. xiii, fig. 3). *Ph. cryptophthalmus*, F. Roemer (12, pl. xiii, figs. 6, 7), and *Ph. cryptophthalmus*, Tietze (17, pl. xxi, fig. 1), have been described by Professor Frech as *Ph.* (*Trim.*) *anophthalmus*. *Ph. cryptophthalmus*, F. Roemer (11, pl. xxxv, fig. 18), and possibly that of Sandberger (15, pl. i, fig. 6*a*), appear to belong to Frech's species. The remaining figures of Sandberger's *cryptophthalmus* represent different species. Salter's *Ph. cryptophthalmus* (13, p. 17, pl. i, fig. 8; 14, pl. ix, fig. 6), which

is in the Museum of Practical Geology [6986], has since been shown by Mr. Whidborne to be *Ph. latifrons* (Bronn) (18, p. 6, pl. i, fig. 8).

Finally, in view of all the foregoing facts, it seems undoubtedly justifiable to apply a new name to the form known up to the present in this country as *Ph.* (*Trim.*) *laevis*. In accordance with Salter's suggestion I propose it be called *Phacops* (*Trimerocephalus*) *trinucleus*, nom. nov. The description and figures given by Salter, together with the above comparative remarks, make it unnecessary to add any further comments.

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VIII.—On a Well-section at Ware House, near Lyme Regis, and the Fossils obtained therefrom.

By A. C. G. Cameron.

WARE, about a mile west of Lyme Regis, is situated on the lower part of the Foxmould Sands of the Upper Greensand, and some distance above the 'West Cliffs', which are formed of Lower Lias clay and limestone.

The site of the well is 395 feet above O.D. It is 117 feet deep, and consists of a shaft sunk to a depth of 48 feet, with a borehole in the bottom 69 feet in depth. The following are particulars of the strata passed through:—

			THICKNESS. ft.	in.	DEPTH. ft.	in.
Upper Greensand.	Zone of *Amm.* [*Schlœnbachia*] *rostratus*.	Foxmould sand	21	0	21	0
		Cowstone	2	0	23	0
		Grey sand with small concretionary stones	5	0	28	0
		Light-green sand, with hard stone 2 ft. 5 in.: *Ammonites rostratus*	20	0	48	0
		Light-green, sticky sand	10	0	58	0
		Hard, coarse sand	3	0	61	0
		Grey sandstone concretion	0	9	61	9
		Sand	1	3	63	0
		Grey sandstone concretion	0	4	63	4
		Sand	0	8	64	0
		Sand	7	0	71	0
		Dark sandstone	1	6	72	6
Gault.	Zone of *Amm.* [*Hoplites*] *interruptus*.	Sandy, micaceous clay	6	10	79	4
		Dark, loamy clay	9	0	88	0
		Greenish, loamy clay	10	0	98	0
		Lighter-coloured, sandy clay	15	0	113	0
		Dark, loamy clay	2	0	115	0
		Brownish, sandy clay	2	0	117	0

Water to the extent of about 2,000 gallons a day was obtained from the shaft, and no further supply was yielded by the boring. Along this range of cliffs, which extends to Whitlands and Bindon, the water is naturally drained away, and wells are not always successful.[1]

In the present record of strata all the beds classed as Upper Greensand may be referred to the zone of *Amm. rostratus*, the remaining 45½ feet to the Gault. The borers were told to look out for the pebbly basement-bed of that formation, but its presence was not detected, neither was there any evidence to indicate that Lias was reached. It is probable, therefore, that as the lowest clay was sandy, the boring did not extend to the base of the Gault, although the observations of Mr. W. D. Lang at Black Ven show that the pebbly basement-bed is there impersistent. On the face of Black Ven the actual junction of the Gault with the Lower Lias lies at a height of 315 feet above O.D., a height nearly 40 feet above that at Ware. The latest measurements taken by Mr. Lang[2] at Black Ven show that below the lowest bed of Cowstones there is about 39 feet of argillaceous strata which may be classed as Gault, while at least 46 feet seems to be the thickness at Ware.

The following Upper Greensand fossils were collected entirely from the sandstone concretions or 'doggers' which were brought up from the well during the progress of sinking. None were obtained from the boring.

Exogyra conica, Sow.
Gryphæa vesiculosa, Sow.
Inoceramus concentricus, Park.
Ostrea sp.
Avicula pectinata, Sow.
Aucellina gryphæoides, Sow.
Pecten quinquecostatus, Sow.
Pecten sp.
Lima tombeckiana, d'Orb.
Arca.
Cucullæa.
Thetis.
Trigonia vicaryana, Lyc.
Turritella.
Crioceras.
Ammonites rostratus, Sow. [*Schlœnbachia*].
Serpula.
Vermicularia concava, Sow.
Necrocarcinus tricarinatus, Bell.
Hoplopsaria.
Plant-remains.

[1] See G. Roberts, *An Account of and Guide to the mighty Land-Slip of Dowlands and Bindon*, 1840, 5th ed., p. 13.

[2] Geol. Mag., 1904, p. 131; 1907, p. 153.

I am indebted to Mr. H. A. Allen for naming the specimens. The list is of interest as containing several species not previously recorded from the Cowstone beds.[1] In this district Selbornian ammonites are rare, consequently the occurrence of *Amm. rostratus*, the zonal fossil, is interesting. The same can be said of *Necrocarcinus tricarinatus*, the crab, whose horizon is now fixed. *Hoploparia longimana*, Sow., had previously been found by De Rance in the Cowstone beds below the roadway between Charmouth and Lyme.[2] *Crioceras* has not hitherto been recorded amongst the local fossils.

NOTICES OF MEMOIRS.

I.—The Discovery of Trias in the Caucasus.

Translated from the Russian by Felix Oswald, D.Sc., F.G.S.

In a preliminary communication by Dr. Th. Černyšev, Director of the Geological Committee of Russia and Foreign Correspondent of the Geological Society, in April, 1907, to the Imperial Academy of Sciences of St. Petersburg,[3] an important addition has been made to the geology of the Caucasus by the announcement of the discovery of beds of Upper Triassic age. Pending the publication of fuller details, which will be published in the Memoirs of the Geological Museum of the Imperial Academy of Sciences, the following abridged translation, which I have made from the Russian of the original article, may help to render this discovery more widely known. It is of special interest to find that on the one hand the fossils are in many cases identical with those of the Upper Trias of Balia Maden in Western Asia Minor, and that on the other hand in the nearest occurrence of Trias to that of the Caucasus, viz. that of Julfa on the Araxes in Armenia, the Upper Trias is altogether wanting, and only the lower division of the Trias is present, overlying Permian.

Dr. Černyšev stated that in 1903 W. I. Worobiev conducted an expedition into the Kuban territory of the Caucasus for the purpose of geological and mineralogical research, especially in the district between the Rivers Laba and Bielaya. Since W. I. Worobiev unfortunately lost his life on the Dzitak glacier the results of his journey have not been published. His collections, journals, and maps were, however, fortunately recovered by N. I. Worobiev in an unharmed condition, and are now in the possession of the Geological Museum of the Academy. Even a cursory examination of Worobiev's collection showed that it would cause a fundamental and essential alteration in the geological map of the Caucasus, and that in particular it would affect the composition, as hitherto known, of part of the Central Caucasus range. The most remarkable discovery, however, made by Worobiev was his finding beds of undoubted Triassic age, which are

[1] See Jukes-Browne, *Cretaceous Rocks of Britain*, 1900, vol. i, p. 187; and H. B. Woodward & W. A. E. Ussher, *Geology of the Country near Sidmouth and Lyme Regis*, 1906, p. 43.

[2] Geol. Mag., 1874, pp. 247, 253.

[3] Bull. Acad. Imp. St. Petersb., ser., vi pp. 277–80.

characteristically represented in his collection; and an entirely new contribution to the geology of the Caucasus results from that part of Worobiev's materials, which has been worked out by Dr. Cernyšev, who described the Brachiopods, and by A. A. Borisiak, his colleague on the Geological Committee of Russia, who identified the Pelecypods.

The starting-point of Worobiev's expedition was from Psebai, on the Little Laba River, whence he proceeded to the source of the Khods River (a left tributary of the Little Laba), where he pitched his first camp. From this place he made a series of excursions in different directions, resulting in an interesting collection of Triassic material.

On the very first excursion, which was undertaken along the Khods River, 3 versts from the camp, in the Mietok Ravine, Worobiev found a small exposure of limestone crowded with valves of *Pseudomonotis ochotica*, Keyserling; and again lower down the gorge, in the same limestone, he observed great quantities of *Terebratula pyriformis*, Suess, *Waldheimia cubanica*, n.sp. (somewhat recalling *W. norica*, Suess), *W.* (*Cruratula*) *labensis*, n.sp. (near to but undoubtedly distinct from *W.* (*C.*) *Beyrichi*, Bittn.), and *Amphiclinodonta Katzeri*, Bittn.

The third excursion was in a southerly direction towards Mt. Tkhach; 2 versts beyond the ford across the Khods River Worobiev investigated limestones extremely rich in Brachiopods; still further on these limestones continued, but without clear exposures. In these Brachiopod limestones he found the following forms:—*Terebratula turcica*, Bittn., *T. pyriformis*, Suess (abundant), *Spiriferina* aff. *kössenensis*, Zugm., *S. Suessi*, Winkler, *Spirigera cubanica*, n.sp., *S. oxycolpos*, Emmr., *Retzia superbescens*, Bittn., *Rhynchonella fissicostata*, Suess, *R.* aff. *fissicostata*, Suess, *R.* aff. *anatolica*, Bittn., *R. labensis*, n.sp., *R. Worobieffi*, n.sp., *Amphiclinodonta Suessi*, Hofm., and other less well-preserved forms.

Subsequently his journey was directed towards the upper Sokhra River, belonging to the system of the Bielaya River. At 5 versts from Mt. Tkhach, towards the left feeder of the Sokhra, he met with a complete section of the Triassic limestone, dipping 15°–25° N.E., showing the following downward succession:—

1. Red and grey limestone, with *Pseudomonotis ochotica*, Keyserling.

2. Red, more compact limestone, with *P. ochotica*, Keyserling, and the following Brachiopods:—*T. pyriformis*, Suess, *W.* aff. *norica*, Suess, *W.* (*Aulacothyris*) aff. *frontalis*, Bittn., *W.* (*A.*) *reflexa*, Bittn., *Spiriferina Suessi*, Winkler, *Spirigera Worobieffi*, n.sp. (undoubtedly belonging to the same group as *S. oxycolpos* and *S. Manzavinii*), *S. oxycolpos*, Emmr., var. *caucasica*, n.var., *Retzia superbescens*, Bittn., *Rhynchonella levantina*, Bittn., *R. Fuggeri*, Bittn.

3. Grey limestone with Crinoid fragments,[1] and the Brachiopods *W.* (*A.*) *reflexa*, Bittn., *R. superbescens*, Bittn.

[1] With regard to this Crinoidal limestone it may be of interest to draw attention to the fact that Dr. Radde in one of his journeys in this region of the Caucasus very nearly anticipated by about thirty years Worobiev's discovery of these Triassic strata, for in the Tiflis Museum (*Die Sammlungen des kaukasischen Museums*, iii, Geologie, p. 171) there is a specimen collected by Dr. Radde from this very district, viz., from the "river-bed of the Matchubusta, a tributary of the Khod river, near Mt. Tkhach".—F. O.

4. Grey, extremely hard limestone, enclosing a bed of greenish-grey, argillaceous limestone, with well-preserved specimens of *Spirigera Manzavinii*, Bittn., and *S. oxycolpos*, Emmr., var. *caucasica*, n.sp.

In the bed of this rivulet, which flows into the Sokhra, there also occurs a dark-grey, nearly black, arenaceous slate, very micaceous, crowded with valves of *Koninckina Telleri*, Bittn., and also containing well-preserved shells of Pelecypods (*Phænodesmia* sp. and *Nucula* cf. *strigilata*, Goldf.).

Even a cursory examination of the above fauna shows that this formation must belong to the Upper Trias, for some of the forms in the foregoing list have been described by Suess and Zugmayer as typical of the Kössen and Starhemberg Beds, e.g., *T. pyriformis*, Suess, *W. norica*, Suess, *Spiriferina Suessi*, Winkler, *S. kössenensis*, Zug., *Spirigera oxycolpos*, Emmr., *R. fissicostata*, Suess, whilst others are representative of the Dachsteinkalk, e.g., *W.* (*A.*) *frontalis*, Bittn., *W.* (*A.*) *reflexa*, Bittn., *R. Fuggeri*, Bittn., thus indicating an equivalence with the Rhætic stage of the Alpine Trias. The fauna, which contains new forms peculiar to the Caucasus, also comprises some characteristic Anatolian forms, described by Bittner in Mysia, e.g., *T. turcica*, *Spirigera Manzavinii*, *R. anatolica*, *R. levantina*, corresponding to the Rhætic stage of the Alps or only slightly older. In addition to the Brachiopods particular attention may be drawn to the numerous well-preserved bivalves (occurring in the same beds), which A. A. Borisiak, after careful comparison with the original fossils in the Geological Museum of the Academy, referred to *P. ochotica*, var. *densistriata*, Teller.

A few words still remain to be said concerning the dark-grey, arenaceous slates, in which there were found abundant valves of *K. Telleri*, Bittn. Since the slates underlie the limestones, and this fossil, which occurs so abundantly, is typical of the Alpine Upper Trias, we may reasonably conclude that the Northern Caucasus possesses a nearly complete series of Upper Alpine Trias.

To judge from some indications given by W. I. Worobiev, the Upper Trias has probably a wide extension on the northern slope of the Caucasus; and a considerable area, which in the absence of palæontological evidence has hitherto been attributed to other formations, may eventually be found to belong to the Upper Trias.

II. Bibliography of Mexican Geology.

IN 1898 the Instituto Geológico de México published as Bulletin No. 10, under the title "Bibliographia Geologica y Minera de la República Mexicana", a list of books and papers on Mexican geology and mining consisting of xii + 160 pages, each 13 × 9 inches and containing 1,953 items, arranged alphabetically under authors' names, with an index of localities and a subject-index, the references extending to papers published from 1556 to the end of 1896. This most useful work has now been continued in Bulletin No. 17 (dated 1908) under the same title with the addition "completada hasta el año de 1904". Bulletin No. 17 consists of xiv + 332 pages, 13 × 9 inches, and contains 4,252 items, arranged, as before, alphabetically under authors'

names, with an index of localities and a subject-index, the references including such as were omitted from Bulletin No. 10, and, as far as possible, all papers and books since published up to the end of 1904. Both bulletins have been compiled by Señor Rafael Aguilar y Santillán. As showing how complete the bibliography is, it may be mentioned that the references to Popocatepetl in Bulletin No. 10 are 28 and in Bulletin No. 17 as many as 72 in number; to Meteorites 55 and 208 respectively.

B. Hobson.

REVIEWS.

I.—The Geology of the Goldfields of British Guiana. By J. B. Harrison, M.A., C.M.G. Published by the direction of the Governor of British Guiana. London: Dulau & Co., 1908.

IT is nearly five and thirty years since the last Government Report on the Geology of British Guiana, that of Brown and Sawkins, saw the light. Comparing that report with Mr. Harrison's work one cannot fail to be struck with the great progress which gold-mining has made in the colony, and the still greater advance in the methods of geological science as applied to the problems of metamorphic rocks and the genesis of ore deposits. We miss, perhaps, that spice of adventure and exploration which makes the older book so readable, but in return we gain much solid knowledge of the complex geological structure presented by this vast extent of little explored country. The book, it may at once be said, is meant for the geologist and the mining engineer rather than for the prospector, though the route details and mining regulations which it includes will be of use even for the latter class of readers.

The colony is divided naturally into three regions. There is a narrow coastal belt of alluvium, much of which is below high-water mark, and was reclaimed partly by the efforts of the early Dutch settlers by means of an elaborate system of dykes. Practically all the rice, cotton, sugar, and rum, which are the staple products of the country, are raised on these flat lands. Behind them are forest-clad plains and grassy downs, where here and there the live rock peeps out from beneath a dense covering (sometimes 200 feet thick) of rotted rock and lateritic surface deposits. The great hinterland, which makes up eleven-twelfths of the area of the colony, consists of forest-covered ranges of elevated hills and flat-topped, terraced, sandstone mountains.

During the eighteenth century the Dutch were aware of the occurrence of gold in a few spots, and Sir R. Schomburg was able to confirm this by his explorations, but Brown and Sawkins saw little of it, and it was only about the year 1886 that the discovery of some rich placers on the Cuyuni and Essequibo Rivers started a temporary boom. Since then the industry has gone ahead, over seven millions of pounds worth of gold having been extracted within the last twenty years, and it is to be expected that when the latest methods of hydraulicking and dredging are brought to bear

on the goldfields of the Colony there will be a long future of prosperity before them.

The gold occurs in two ways—in placers or alluvial deposits and in reefs or mineralized masses of igneous rock. The placers are not true gravels of alluvial origin, but merely the rotted surface accumulations covering the gneisses and other igneous rocks which make up the greater part of the country. This material is very thick, and often a considerable overburden covers a foot or two of pay dirt on the bed-rock. It is purely of local derivation, except that the rain-soaked clays creep slowly down slopes after the wet season. The gold is got by sluicing, so that it is a poor man's field, and is mostly very fine, though some large nuggets have been found. The river alluvia also are auriferous, but they have a much more limited distribution. Clearly, if much of the sedentary surface deposits of British Guiana contains gold in payable quantities, this will be an important goldfield, but the dense forests render exploration very difficult. The gold in these alluvia comes from the country rock, and Mr. Harrison is of opinion that it is principally derived from the greenstone or diabase. He has made a very large number of assays of the different types of rock that occur in the goldfields, and has found gold in many of them, but principally in the basic rocks. He holds that by concentration through weathering and solution the gold content of the alluvia has been increased, a proposition certainly very reasonable in itself but excessively difficult to prove in the circumstances under which the gold occurs.

The gold-reefs of the Omai, Barima, and other mines are of a different category. They are associated with pegmatites, alaskites, and albite aplites which recall many well-known auriferous deposits like those of the Alaska Treadwell. Many of them show evidence of pneumatolytic origin. But in the quartz reefs there is a tendency for the gold to occur in quantity only at the junction of diabase with gneiss or granite or other country rock, a fact which, seeing that the basic rock is the latest intruder, suggests again that it is the real ore-bringer. Mr. Harrison states all the available evidence very clearly. He admits the importance of the granites and aplites as fully proved in certain cases; but he is strongly of opinion that much of the gold came in with the basic rocks. The impartial caution with which he handles the problems of ore-genesis deserves great praise, and his wide knowledge of the country gives his opinions much weight.

Since 1890 small diamonds have been found in considerable numbers in various parts of British Guiana. They occur in gravels which may lie 70 or 80 feet above the rivers, but they have never yet been traced to their parent rock. From their distribution it seems probable that most of them have been derived from the sandstone and conglomerate which overlie the gneisses, but this can only be a mediate source. At Omai they were obtained in "a blue clay, a product of the decomposition of gabbro or diabase in situ". Mr. Harrison made experiments on some of the mica-gabbro of Mazaruni and obtained a residue of minute grains, insoluble in acids, which from their optical and other characters he believes may have been diamonds. Unfortunately they were too small and too few to yield conclusive

evidence. The results are interesting, and the experiment is well worth repeating; it suggests a resemblance to the occurrence of diamonds in epidiorite in Australia.

The groundwork of the geology of the country is a complex of gneisses, amphibolites, and schists of many different kinds, but apparently all igneous. This has been reduced by erosion to a peneplain and covered by extensive deposits of sandstone, relics of which now form flat-topped mountains. Some of these, like Mount Roraima, have a considerable elevation. The sandstones are probably Cretaceous, though in British Guiana they have not yielded any fossils. The various Palæozoic rocks which are known in the Amazon Valley apparently do not occur in British Guiana. At the base of the sandstones there are dykes and sills of diabase which Mr. Harrison suggests may belong to the Tertiary Cordilleran or Pacific magmas, but opinions differ as to the relations of these rocks, and there may be two diabases, one older and one newer than the sandstones. The petrographical characters of the fundamental complex are very fully described. They have many affinities to the Lewisian rocks of North-West Scotland. The quartz diabases are excellent representatives of a type which has been repeated with identical characters at many different epochs over the whole world. Many analyses of the metamorphic and igneous rocks are given, and the excellence of Mr. Harrison's analyses is known to all petrologists. Some photomicrographs appear, unfortunately not accompanied by any descriptions. The volume also would be improved by the insertion of a map, if only as a guide to the topographical details. In spite of minor defects the work deserves high praise; it shows how much can be done, even in a country where the physical difficulties are extremely great, by the continued researches of a resident geologist. Even the most accomplished visitor can do little in such a region. No part of the British West Indies is so well described as British Guiana, and in the whole of South America there are only a few small portions so well known in a geological sense. We have reason to be thankful for the intelligent policy of the colonial administration which has made it possible for scientific work of this character to be carried to completion.

J. S. F.

II.—Text-Book of Petrology. By F. H. Hatch, Ph.D. Fifth Edition. pp. xvi + 404, with 130 figures. London: Swan, Sonnenschein, & Co., Ltd. New York: The Macmillan Co. 1909. Price 7*s.* 6*d.* net.

IT is eighteen years since Dr. Hatch issued a slim volume entitled *Introduction to the Study of Petrology*. So immediate was its success, and so great the demand for it, that only two years later a second edition appeared under the more extensive title which has been retained in the subsequent editions. Although two editions have been issued during the intervening years, they are merely reprints of the second, and there has, therefore, been really no fresh edition since the second. These years have marked a period of great activity in petrological science. Important improvements have been introduced into the petrological microscope, and more subtle methods have been

devised for the discrimination of the mineral species constituting a rock-section, and the resulting discoveries have led to not insignificant changes in the classification of rock species and to greater refinement in subdivision. As the years passed it became increasingly evident that a complete revision was necessary if the work was to retain its former position among petrological textbooks. This has now been done, and the present edition may confidently be recommended to the student who requires a sound, yet not too abstruse, grounding in the characteristics of the several species of igneous rocks, and in some of the simpler methods for their discrimination. Examples have been freely drawn from recent research, such as, for instance, Harker's admirable memoir upon the Tertiary igneous rocks of Skye.

While the general framework of the book remains much the same, there is scarcely a paragraph that has not undergone alteration. In the opening pages the student who is desirous of wider reading will find a list of the principal works on the subject. In Part I the author discusses the physical characters of rocks, such as their mode of occurrence, their macro- and micro-structure, and their composition. In Part II he deals with the rock-forming minerals and their characters. Some space is devoted to the phenomenon of double refraction, upon which depends the usual method of distinguishing the minerals seen in a thin section, and a list is given of the principal rock-forming minerals, arranged according to their maximum birefringence. Since petrological students generally acquire some knowledge of mineralogy and crystallography, it would have been advantageous if the refractive properties had received somewhat fuller treatment. In the description of the minerals the mean refractivity is given, and the double refraction is characterized as 'strong', 'moderate', or 'weak': it would have taken no more space to have stated the greatest and least of the refractive indices, and the information would have been fuller and more complete. In the description of the mineral species attention is, of course, chiefly paid to their appearance as seen in rock-sections. In Part III we find a clear and lucid discussion of the igneous rocks, arranged according to the plutonic, hypabyssal, and volcanic groups. The characters and distinguishing features of each family are pointed out, typical analyses are quoted, and happy use is made of Iddings' elegant diagrammatic method for representing the composition of the rocks constituting a family. The reproductions of micro-photographs, prepared by Mr. R. H. Rastall from sections in the Students' Series in the Sedgwick Museum at Cambridge, facilitate the understanding of the text. The account of the distribution of igneous rocks in the British Isles, which was previously included in this part, has now been expanded and forms Part IV. This feature of the book renders it peculiarly valuable to students in this country. A useful table, prepared by Mr. R. H. Rastall and Mr. J. Romanes, for the determination of the minerals in a thin section by means of their optical properties is appended, and a full index brings the work to a close.

Dr. Hatch has endeavoured to make the subject intelligible to

any reader, even if approaching it for the first time; the language employed is as simple as possible, and the meaning and derivation of all technical terms are stated. The publishers have likewise done their part well; the printing and general appearance of the book are all that could be desired.

III.—The Geology of the Country near Oban and Dalmally (Explanation of Sheet 45, Scotland). By H. Kynaston, B.A., and J. B. Hill, R.N.; with contributions by B. N. Peach, LL.D., F.R.S., J. S. Grant Wilson, H. B. Muff, B.A., and E. B. Bailey, B.A., with Petrological Notes by J. J. H. Teall, D.Sc., F.R.S., and J. S. Flett, M.A., D.Sc. pp. vi, 184, with 2 text-illustrations and 7 plates. Ordnance Survey Office, Southampton, 1908. Price 2*s.* 6*d.*

THIS memoir deals with a very interesting and picturesque Highland district, one which (to quote Mr. Kynaston) "shows a diversity of rock type and structure, combined with a variety of scenic feature, which is seldom seen in any other area of equal extent". Visitors to Dalmally, Loch Awe, and the Pass of Brander, to Taynuilt, Connel Ferry, and Oban, who are interested in the physical features and wish to know something of the story of the rocks, will, however, find very stiff reading in this memoir. The fundamental rocks, the Highland metamorphic schists, limestones, and quartzites, with intruded epidiorites, occupy the eastern and north-western portions of the area; rugged mountain masses of granite rise in Ben Cruachan to 3,689 feet, and dominate the central and northern parts of the area; while the great series of volcanic rocks associated with the Old Red Sandstone and conglomerate of Oban and Dunstaffnage, a series consisting of andesites, rhyolitic felsites, agglomerates, and tuffs, extend over most of the western part of the area. Glacial deposits, raised beaches, and a tiny tract of Carboniferous rocks complete the list of main formations. Again quoting from Mr. Kynaston, "So varied an area can hardly fail to constitute a wide field of geological interest and inquiry, and to afford the materials of problems, metamorphic and igneous, structural and physical, of which we will now proceed to give some account in the following chapters." As a matter of fact, eight of the fourteen chapters are almost wholly petrological, and they make up about three-fourths of the volume. They contain matter of more than local interest with regard to the subjects of folding and progressive regional metamorphism, and of contact metamorphism; and in the accounts of the Kentallenite of Glen Orchy, and of the Tertiary Camptonites and Monchiquites; but they appeal essentially to the specialist.

An excellent view of the Pass of Brander with its screes is given in the frontispiece, and it is interesting to learn that the gorge corresponds with a line of fault, and that it is owing to the gradual excavation of the pass that the waters of Loch Awe are now drained through it instead of finding their way out, as they formerly did, at the south-western end of the loch.

We are told that the great granite masses of Ben Cruachan and Blackmount "have been intruded into the metamorphic series at

a later date than the movements which caused their foliation"; and a fine view is given of "Coire Creachainn" (elsewhere apparently spelt Cruachan).

It is difficult, however, to find in any one place a good description of the rocks and features depicted in the above-mentioned plates, nor have we come across any discussion of the probable ages of the granites.

Around Oban, as pointed out, the Lower Old Red Sandstone rests on black schists of the Highland Series, and the basal portion consists of coarse conglomerates which pass upwards into sandstones and shales. The conglomerates are remarkable for the immense pebbles and boulders of andesite which they contain, some of the blocks weighing nearly half a ton. Hence the volcanic phenomena of Lorne did not commence with the lowest lavas of the plateau, which overlie the conglomerates and some of the sandstones, but "lava-flows must evidently have been erupted before any of the visible conglomerates began to be formed". In the sandstones immediately above the conglomerates remains of *Cephalaspis*, *Pterygotus*, and *Kampecaris* have been found.

The evidence of the presence of Carboniferous rocks at the Bridge of Awe, at the north-west end of the Pass of Brander, was established during the course of the Geological Survey. The strata, previously regarded as Old Red Sandstone, consist of conglomerates overlain by variegated marls, purple shales, and sandstones. Some fossils have been found in the shales, and they include *Asterocalamites scrobiculatus*, Schl., identified by Dr. Kidston, and a mollusc almost identical with *Modiola Macadami*, Portl., determined by Dr. Peach. The fossils favour the view that the beds are Lower Carboniferous. The superficial deposits are not extensive. Mr. Kynaston remarks that "the glens, as a rule, are narrow and the hills bold and steep, so that surface accumulations would be apt to be rapidly carried away in a climate characterised by a high rainfall".

Abundant evidence of glaciation is met with in the polished and striated surfaces of the rocks, and in the mounds of morainic material which fill the glens. The phenomena are attributed for the most part to the period of later glaciation, and this applies also to the small areas of boulder-clay in the Kilchrenan area and elsewhere. Fluvio-glacial gravels, which occur in places, have been traced into the 100 foot beach.

Raised beaches at elevations of 50 and 100 feet are noticed. The cliffs bounding the 50-foot beach are here and there hollowed out into caves, some of which "bear evidence from their contents of having been inhabited from before historic times down to the present". A little more information might perhaps have been given respecting them. We notice in the Bibliography that there are titles of papers on the caves, but there is no reference to these in the text. The same remark unfortunately applies to many other papers in the Bibliography, and we are at a loss to know to what extent others have contributed to a knowledge of the geology of the district.

Economic Geology occupies one chapter of two pages, relating to granite and other building-stones, slate, lime, road-metal, and material for pottery manufacture. Peat is dealt with in the previous chapter, but there is no mention of water-supply.

IV.—The Water Supply of Kent: with Records of Sinkings and Borings. By William Whitaker, B.A., F.R.S.; with contributions by H. F. Parsons, M.D., H. R. Mill, LL.D., and J. C. Thresh, M.D. 8vo; pp. v, 399, with rainfall map, 8vo; cloth. 8*s.* 6*d.*

The Water Supply of Bedfordshire and Northamptonshire, from underground sources: with Records of Sinkings and Borings. By Horace B. Woodward, F.R.S., and Beeby Thompson, F.G.S., F.C.S.; with contributions by H. R. Mill, LL.D. 8vo; pp. vi, 230, with two rainfall maps, 8vo; wrapper. 4*s.* 6*d.* Published at the Ordnance Survey Office, Southampton.

DURING the past ten years the Geological Survey has issued memoirs on the Water Supply of Sussex, Berkshire, Lincolnshire, East Yorkshire, and Suffolk; and previously in Mr. Whitaker's *Geology of London*, vol. ii (issued in 1889), there was printed a record of the strata passed through in wells and borings over a large area in and around the metropolis and in the lower part of the Thames Valley.

We have now before us the two memoirs above noted. That on Kent is probably the most complete work on local water-supply ever published. As we are reminded by the Director of the Geological Survey, the author, Mr. Whitaker, took a large share in the original geological mapping in that county, and has since added very much to our knowledge of its underground structure.

So greatly, indeed, has this knowledge been increased by the results of recent borings that the county has now perhaps a fuller list of formations than any other. At the surface there is considerable variety of Recent and Pleistocene deposits, some remnants of Pliocene, a nearly complete series of Eocene formations, and a continuous series of Upper and Lower Cretaceous rocks; below ground all the Jurassic divisions, as well as representatives of Trias, Coal-measures, Devonian, and Silurian, have now been proved.

The information which Mr. Whitaker has assiduously gathered for many a year is methodically arranged and tabulated in his volume. He gives full particulars relating to springs, swallow-holes, and the intermittent streams known as Bournes or Nailbournes—all matters that have considerable geological interest. The water-bearing capacities of the formations from the shingle of Dungeness to the Hastings Beds are duly described, and the supplies taken from springs and wells are separately indicated. Maidstone and Folkestone are the only places which take large supplies from springs, and these supplies are supplemented by well-water. The greater part of the water-supply of Kent is drawn from the Chalk; the Kent Water Company (now part of the Metropolitan Water Board) supply a population of more than 680,000 people, pumping from wells between 18 and 19 millions of gallons of water daily. As Mr. Whitaker points out, this is the largest supply in the world obtained from underground sources.

The records of the strata passed through in shafts and borings are arranged in three divisions: those for water, those for coal, and those for sundry other purposes (various trial-borings).

Of special interest are the borings for coal, and details of the Secondary strata at Ottinge, Hothfield, Penshurst, and Old Soar,

contributed by Professor W. Boyd Dawkins, are now for the first time published. These borings, however, did not extend to the Palæozoic floor. We should have been glad to see details also of the Secondary strata passed through at the Ellinge, Ropersole, Waldershare, and Fredville borings, which reached Coal-measures, and of the Brabourne boring, which reached Devonian or possibly Silurian (as suggested on p. 383). Records of the Dover pits are given, summarized to some extent from accounts previously printed.

Many analyses of water have been contributed by Dr. Parsons, on behalf of the Local Government Board, and by Dr. Thresh, while the statistics of rainfall have been prepared by Dr. Mill. A Bibliography together with Miscellanea and Addenda form the concluding portions of this volume.

In the memoir on the Water Supply of Bedfordshire and Northamptonshire the Geological Survey has had the advantage of the services of Mr. Beeby Thompson, whose researches on the geology of Northamptonshire, from a practical as well as scientific point of view, are well known. He has contributed, in addition to numerous records of well-borings, a full account of the springs around Northampton, and of the various schemes for supplying the town with water from the date of the earliest record, which was in the thirteenth century. He has also written notes on the characters of the Northamptonshire waters, and supplied records of original analyses. The particulars relating to Bedfordshire have been arranged and classified by Mr. H. B. Woodward, who has written the general outline of the geology of the two counties, with notes by Mr. Thompson and Mr. Jukes-Browne. Various records of wells and borings have been contributed by Mr. Whitaker and Mr. A. C. G. Cameron, and the sections on rainfall have been drawn up by Dr. H. R. Mill. We note on p. 64 that the grouping "Alluvial Drift" is printed in mistake for Glacial Drift. The volume concludes with a Bibliography.

V.—The Geological Society of London.

THE record of "The Centenary of the Geological Society of London", prepared by Professor W. W. Watts, late senior Secretary of the Society, has been issued uniform with the Quarterly Journal (pp. vi, 166) at the price of 2*s.*, and with an excellent portrait of Sir Archibald Geikie. The main features are the report of the reception of the delegates, the addresses of congratulation from individuals and institutions representing all parts of the world, and the presidential address delivered by Sir A. Geikie.

Most of the addresses are in English, but others are in Latin, French, German, and Dutch. Many of them were elaborate in design, of great beauty and artistic merit.

The oldest institution that tendered congratulations was the Royal College of Physicians, now in the 389th year of its corporate existence. It was represented by Dr. Michael C. Grabham, who also issued an independent address to the President and Fellows entitled "The First Hundred Years of the Geological Society of London". In this essay the author remarks "we may surely ask

the mathematician, if his mill has to be reset, to deal gently with the geologist, and to afford him all reasonable scope for his vast meditations". He adds, however, in a side-note, "'Deal gently and without shedding of blood' was the mediæval formula for burning alive." The inference perhaps was not intended. In the numerous addresses printed in the volume before us there are many references of historic interest to the early workers in different lands, and to those who helped in the establishment of the Geological Society of London.

In his interesting Presidential Address Sir A. Geikie dealt with the history of geological research prior to the foundation of the Society, and showed that, as a recognized branch of science, geology is not much older than the Society itself.

In addition to the matters already mentioned, the Centenary volume contains a record of the dinners, conversazione, visits to museums, and of excursions made to different parts of the country. The longer trips were not popular, but the single-day excursions were for the most part well attended.

The total number of those attending the Centenary was 307; of these there were about 50 Fellows who came as delegates, and 111 other Fellows, out of a total number of between 1,251 and 1,278 (the full number of Fellows at the end of the years 1906 and 1907 respectively). Thirty ladies were present.

The volume is a valuable record of an historic gathering, most carefully prepared and edited by Professor Watts with the assistance of Mr. Belinfante.

REPORTS AND PROCEEDINGS.

Geological Society of London.

Annual General Meeting.

February 19, 1909.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The Reports having been received and adopted, the President presented the Wollaston Medal to Mr. Horace Bolingbroke Woodward, F.R.S., addressing him as follows:—

Mr. Woodward,—The Wollaston Medal is awarded to you in recognition of researches conducive to the interests of the Society in particular and to the science of Geology in general, especially in relation to the Jurassic rocks of Britain and the *History of the Geological Society*.

No one possesses a more encyclopædic knowledge of the Geology of England and Wales than yourself, and your well-known book on this subject, distinguished by its clear and orderly presentation of a vast collection of facts, is indispensable to every English student of our science.

The Jurassic System, as developed in this country, has long occupied your attention, and you have given an admirable account of it in your three great volumes on *The Jurassic Rocks of England and Wales*, a work which embodies your own personal observations, and fully and impartially records every fact of importance contributed by other investigators.

The invaluable History of the Society which you prepared for our Centenary Celebration is a mine of information, and at the same time a continuous and consistent story well told. The heroic figures and the battles of long ago are brought vividly before our eyes; and the human side of our great predecessors is faithfully touched in with many a quaint saying, odd mannerism, and witty story. As we read we are conscious of a deepening appreciation of the great and lovable nature of the men who helped to found and build up our science, and an increased pride in the Society which they have transmitted to our care.

Your retirement from the Geological Survey will doubtless be merely the introduction to a new sphere of activity; the good wishes of the Society will follow you there, and we hope that you will live long to enjoy the powers conferred upon you by your well-earned leisure.

Mr. Woodward replied in the following words:—

Mr. President,—In receiving from your hands the Wollaston Medal I feel intensely gratified that my work has been adjudged by the Council to be worthy of this great honour.

I cannot claim to be one who engaged in the "Pursuit of Knowledge Under Difficulties", as the Society in my early days, and the Geological Survey afterwards, directed my steps and made the pathways smooth. Thus, whether under command or away from official control, ambition was stirred to make as full acquaintance as possible with the Geology of this country. In almost every part of it we have the advantage of following in the footsteps of previous geological workers, and as progress could not be made without heed to the lessons which they have taught, it is natural that some of us should be led from the rocks into historical and biographical trackways. In these directions, from the field to the study, my tasks have conducted me; and, while I recognize that, as a recipient of this award, I am highly privileged, I rejoice in the weight attached to researches which indicate how much we are indebted to those who have gone before us.

I thank you, sir, for the very kind words with which you have accompanied this presentation.

The President then presented the Murchison Medal to Professor Grenville A. J. Cole, F.G.S., addressing him as follows:—

Professor Cole,—In awarding you the Murchison Medal the Council wish to express their appreciation of the value of your contributions to Geology in general and especially to Petrology.

You have combined, in the happiest manner, work in the laboratory with observations in the field; in addition, your petrological studies have been so arranged as to lead naturally to comparative results, and by visiting allied areas you have caused each in turn to throw light upon the other. The tachylytes of Scotland thus led you to the variolitic masses of the Hautes Alpes, and Hungary was thus made the basis for the description of the rhyolites of Antrim.

Impressed by the modifications suffered by igneous magmas through the absorption of foreign material, you were led to important conclusions with regard to the granite of Slieve Gallion in Londonderry; and in Tyrone and Donegal you found in the phenomena of igneous intrusion an explanation of the structure of gneisses which had been previously attributed to dynamo-metamorphic action.

Since 1905 you have been called on to direct the work of the Geological Survey of Ireland, and have endeavoured to connect the study of soils with the underlying drift and older rocks.

Not the least merit of your work is the endeavour to present your results in a pure and simple literary style.

We have made many excursions together on Irish soil, and I have had frequent opportunities to observe, not without admiration, how keen is your interest, how untiring your enthusiasm, and how ample your enjoyment when brought face to face with the knotty problems of the field.

The memory of our association in the past adds to the pleasure with which I hand you the Murchison Medal.

Professor Cole replied in the following words:—

Mr. President,—I beg to thank you and the Council of the Geological Society for the generous and unexpected award made to me to-day. In your friendly references

to my work you have fully appreciated the aim of my petrological studies, although I fear that you have been unduly kind to the performance. The illustrious founder of the medal which I now receive laid stress, in common with his contemporaries, on the necessity for the comparison of geological phenomena in many lands besides our own. Travel, it was urged, was one of the first duties of a geologist, and this was never lost sight of in the training that I received from my own revered master, Professor Judd. In my far smaller way I have always endeavoured to realize that a rock-specimen is not a mineralogical curiosity, but a portion of this very vital globe on which our destinies are cast. It is an especial pleasure, Mr. President, for me to receive this encouragement from your hands, since the work so kindly recognized has been mainly done in Ireland. When, eighteen years ago, I entered that country as a stranger, you freely placed before me the results of your own enquiries, and year by year you stimulated me by your energy in research. May I venture also to think—you, sir, have opened the way for me to say it—that the Geological Survey of Ireland, which has so kindly received me as a colleague, becomes again to-day associated with the historic name of Murchison?

In presenting the Lyell Medal to Professor Percy Fry Kendall, M.Sc., the President addressed him as follows:—

Professor Kendall,—The Lyell Medal has been awarded to you by the Council as a mark of honorary distinction and as an expression on the part of the Council that you have deserved well of the science, especially by your researches into the Glacial Geology of England.

The success which has attended your performance of the arduous duties connected with the Professorship of Geology in a young University has only been achieved by strenuous labour; that you have been able at the same time to accomplish so much in the field of research is a striking testimony to your indomitable energy.

Your delightful account of the Geology of Yorkshire, with its wealth of detail and breadth of view, is a model of its kind, and your report to the Royal Commission on the Concealed Coalfields of North-Eastern England is important, both from a theoretical and from a practical point of view; but to the Fellows of this Society you are probably better known by your long-continued and successful researches into Glacial phenomena, and especially by your brilliant account of the Glacial lakes of Cleveland.

I sincerely trust that the future may have in store a larger share of time and opportunity for the exercise of your original powers.

Professor Kendall replied in the following words:—

Mr. President,—I thank the Council most heartily for the honour which it has done me in the award of this valued distinction, and you, sir, for the generous terms in which you have conveyed it.

My lot as a geologist has been cast in very pleasant places. I have been trebly fortunate in my teachers, for, while my studies in early manhood were directed by such distinguished exponents of our science as my friend and master, Professor Judd, and his lieutenant, Professor Grenville Cole, I owe not a little to the fact—until this moment unknown to you—that at a still earlier period in my career I had the advantage of attending a course of lectures in the City of London delivered by you.

This inspiration fanned to a glow the fire of enthusiasm for Geology that is among my earliest recollections, and will, I doubt not, last to the end of my life.

I have found in Yorkshire a wide and varied field, replete with problems of the highest scientific interest and economic importance, which press so insistently for solution that the temptation has been great to pass on from one half-solution to another. It is most gratifying to find that my small measure of achievement has commended itself to the Council of the Geological Society.

I must not forget an acknowledgment of the debt that I owe to the many enthusiastic brother-geologists in the county of my adoption, who have helped and encouraged me in the field, and by frank and friendly criticism have saved me from not a few downright blunders.

The President then presented the Bigsby Medal to Dr. John Smith Flett, M.A., addressing him as follows:—

Dr. Flett,—In a series of masterly memoirs published during the past thirteen years, you have greatly extended our knowledge of the geology and petrography of Great Britain, particularly of Scotland and Cornwall.

The responsible post of Petrographer to the Geological Survey has brought you many opportunities, of which you have made such excellent use that you have come to be generally recognized as a worthy successor to Dr. Teall, and than this I know of no higher praise.

You have not confined your studies to these Islands, but have given us descriptions of the rocks of remote parts of the world. At the call of duty and in the pursuit of Science you visited, in company with Dr. Tempest Anderson, St. Vincent and Martinique, and gathered your facts amidst the explosions of la Montagne Pelée. From my own experience of other active, if less ferocious volcanoes, I know something of the demands which this makes on the coolness and courage of the observer. It is, therefore, with the sympathy of a comrade in arms that I hand you this Medal in the name of the Council.

Dr. Flett replied in the following words:—

Mr. President,—The honour which the Society has done me by awarding to me the Bigsby Medal is one of which I am deeply sensible. I can assure you, sir, that it will be my endeavour to see that the stimulus that it gives to scientific work, the injunction "not to rust unburnished, but to shine in use", will not pass unregarded. In the study of British rocks, principally the igneous and metamorphic, I have had exceptional advantages; for I have received the kindest assistance from my colleagues on the Geological Survey, and especially from Dr. Teall, who also by his example has placed before me the highest ideals of thoroughness and accuracy in investigation. The labour spent in research is in the best sense its own reward, but the pleasure which I have derived from it has been greatly increased by the approbation which you have expressed this afternoon in handing me this Medal.

In presenting the Prestwich Medal to Lady Evans, the President addressed her as follows:—

Lady Evans,—The Council has awarded to you the Prestwich Medal *in memoriam* of Sir John Evans.

It is now fifty years since Sir John Evans, in company with his lifelong friend Sir Joseph Prestwich, visited the scene of Boucher de Perthes's famous discoveries at Abbeville. The results of that visit in its effect upon the whole range of human thought would be difficult to estimate: one of them is apparent in the increasing growth of that new branch of Science—the Anthropology of the Pleistocene Epoch—which Sir John Evans did so much to create.

This award commemorates in some sense the joint labours of the two friends; that it was not made earlier is due to Sir John Evans's long-continued and self-denying services on the Council.

We esteem ourselves fortunate that you, Lady Evans, who shared his interests, and are yourself an antiquary, are able to be present on this occasion, and in handing you this Medal I desire to express, on the part of the Society, our deep appreciation of the unceasing devotion and affectionate solicitude with which its interests were watched over by our lost leader, whose memory we shall long preserve.

On behalf of Lady Evans, Mr. Lewis Evans replied in the following words:—

Mr. President,—Speaking on behalf of Lady Evans and my late father's family, I have to express our great appreciation of the honour which the Society has paid to his memory in awarding to her the Prestwich Medal; we also recognize the special fitness of the award because of the long, unbroken, and most intimate friendship between Sir Joseph Prestwich and my father; and, on account of his knowledge of medallic art, my father was chiefly responsible for the design of this medal.

To you, sir, I wish to tender our special thanks for your kind and sympathetic words on the occasion of this presentation, terminating in so graceful a manner the fifty-year-long connection between my father and your illustrious Society.

The President then handed the Balance of the Proceeds of the

Wollaston Donation Fund to Mr. Arthur John Charles Molyneux, F.G.S., addressing him as follows :—

Mr. Molyneux,—Thanks to the enterprise of scientific explorers, the Continent of the Sphinx is slowly yielding up its mysteries.

One of these explorers we are glad to welcome in your person on this occasion. We owe to your exertions important contributions to our knowledge of the geology of Southern Rhodesia and Bechuanaland; all of these are distinguished by carefulness of description and caution in inference.

You were the first to give a scientific account of the Victoria Falls, and to explain their origin. When the British Association visited the Falls in 1905, your work was very searchingly criticized; along with my fellow-geologists I had the satisfaction of recognizing its faithfulness to fact as well as its theoretical adequacy.

We are all glad to find that the climate of Africa has treated you leniently, and we hope that when you return you will be able to throw further light on that still mysterious continent.

In presenting the Balance of the Proceeds of the Murchison Geological Fund to Mr. James Vincent Elsden, B.Sc., the President addressed him in the following words :—

Mr. Elsden,—The balance of the Murchison Geological Fund has been awarded you by the Council on account of your work among the Igneous Rocks of Wales, and to encourage you in further research.

Since your earliest work in 1883 you have continued to make welcome additions to our knowledge, particularly in the application of geology to the arts, and you have enriched the literature of British petrography by excellent papers on the igneous rocks of the Lleyn district, Llyn Padarn, and Pembrokeshire. These contributions are distinguished by their philosophic treatment of accurately described data, in the light of the most recent advances in chemistry and physics.

We wish you health and opportunity to continue your important work of research.

The President then presented one moiety of the Balance of the Proceeds of the Lyell Geological Fund to Mr. Herbert Brantwood Muff, B.A., addressing him as follows :—

Mr. Muff,—A moiety of the Balance of the Proceeds of the Lyell Geological Fund has been awarded to you in recognition of your researches among the Pleistocene deposits and the ancient rocks of Scotland and Ireland.

As a result of your researches on Glacial deposits in this country, you have indicated a lower limit for the ancient snow-line, at least in the vicinity of Bradford, where it did not descend beyond 1,500 feet above the present sea-level; and in company with Mr. W. B. Wright you have established a pre-Glacial limit to the sea along the southern coast of Ireland, which corresponds in a remarkable manner with that now existing.

You have also carried your hammer into the tropics, and published a valuable report on the Geology of British East Africa.

Recently, in conjunction with Mr. Carruthers, you have investigated the West of Ireland, where you have discovered a thick series of Arenig rocks, and shown that the crystalline schists of Connemara were metamorphosed before the Arenig Epoch, and probably before the Cambrian Era.

You are now engaged in studying the perplexing problems of the Western Highlands of Scotland. May your labours be crowned with equal success!

In handing the other moiety of the Balance of the Proceeds of the Lyell Geological Fund, awarded to Mr. Robert George Carruthers, to Professor E. J. Garwood, Sec. G.S., for transmission to the recipient, the President addressed him in the following words :—

Professor Garwood,—The Council have assigned a moiety of the Balance of the Lyell Geological Fund to Mr. R. G. Carruthers in recognition of his work on the Carboniferous Corals, and to stimulate him to further research.

The task of subdividing the Carboniferous Limestone into definite zones has engaged the energies of a brilliant band of investigators, and no one has contributed

more fundamental data than Mr. Carruthers. The recognition of distinctive characters among forms apparently so indefinite as the corals is a difficult problem, taxing to the utmost the judgment, skill, and patience of the observer. It is one which he has undertaken, and so far with conspicuous success.

In asking you to transmit this award to Mr. Carruthers, I would beg you to assure him of the cordial interest taken by the Council in the progress of his labours.

The President then proceeded to read his Anniversary Address, giving first of all Obituary Notices of several Fellows and Foreign Members deceased since the last Annual Meeting, including Dr. H. C. Sorby (elected a Fellow in 1850); Sir John Evans (el. 1857); W. H. Hudleston (el. 1867); Professor A. J. Gaudry (elected Foreign Member in 1874); Professor A. de Lapparent (el. F.M. 1897); Dr. F. Schmidt (el. F.M. 1895); General J. F. N. Delgado (el. F.M. 1899); Professor H. G. Seeley (el. 1862); Sir Thomas Wardle (el. 1863); and Joseph Lomas (el. 1897).

He then dealt with the question of Time, considered in relation to Geological Events and to the Development of the Organic World, referring, first of all, to recent evidence in proof of the extreme rigidity of the interior of the Earth. He remarked that Mr. Strutt's method of estimating the age of sediments by reference to their radio-active constituents was of great promise, but a long series of concordant observations would be required to inspire absolute confidence in its results. Professor Joly's method of determining the age of the Ocean, based on the ratio of the amount of sodium which it contained to that annually contributed to it by rivers, was subjected to a detailed analysis, in the course of which it was pointed out that the sodium contained in river-water existed chiefly as sulphate or chloride, though theoretically it should be in the state of carbonate. The origin of the chlorine was manifold; some was traced to salts borne by the winds from the ocean, some to supplies from ancient desert-lakes, and some to juvenile waters escaping as hot springs or impregnating the vadose waters underground. The probable limits for the age of the Ocean were 80 to 170 millions of years.

An examination of the sedimentary series, where developed to their maximum thickness, gave a period of 35 millions of years, on the assumption that deposition had proceeded at a rate of 1 foot in a century. Explanations of the discrepancy were suggested, and it was proposed to divide stratigraphical time into two moieties, each of 40 millions of years duration. The earlier or pre-Cambrian moiety was termed the Protæon, the later or post-Cambrian the Neatæon. Using the scale of 1 foot in 100 years as a rough chronological measure, it was applied to illustrate the rate of evolution in the case of the Equidæ and the chief varieties or species of man. Though relatively rapid, when considered in connection with some other groups of organisms, this was shown to be so slow, when measured in terms of years, that perceptible differences in a linear ancestral series would have required tens of thousands of years for their production.

The Ballot for the Council and Officers was taken, and the following were declared duly elected for the ensuing year:—Council: Charles William Andrews, B.A., D.Sc., F.R.S.; George Barrow; Professor William S. Boulton, B.Sc.; Professor Samuel Herbert Cox, F.C.S., Assoc.R.S.M.; Professor Edmund Johnston Garwood, M.A.; Sir Archibald Geikie, K.C.B., D.C.L., LL.D., Sc.D., Pres.R.S.;

Alfred Harker, M.A., F.R.S.; Robert Stansfield Herries, M.A.; Finlay Lorimer Kitchin, M.A., Ph.D.; George William Lamplugh, F.R.S.; John Edward Marr, Sc.D., F.R.S.; Horace Woollaston Monckton, Treas.L.S.; Richard Dixon Oldham; George Thurland Prior, M.A., D.Sc.; Professor Sidney Hugh Reynolds, M.A.; Professor William Johnson Sollas, LL.D., Sc.D., F.R.S.; Aubrey Strahan, Sc.D., F.R.S.; J. J. Harris Teall, M.A., D.Sc., F.R.S.; Richard Hill Tiddeman, M.A.; Professor William Whitehead Watts, Sc.D., M.Sc., F.R.S.; Henry Woods, M.A.; Arthur Smith Woodward, LL.D., F.R.S., F.L.S.; and George William Young.

Officers:—*President:* Professor William Johnson Sollas, LL.D., Sc.D., F.R.S. *Vice-Presidents:* George William Lamplugh, F.R.S.; Horace Woollaston Monckton, Treas.L.S.; J. J. Harris Teall, M.A., D.Sc., F.R.S.; and Professor William Whitehead Watts, Sc.D., M.Sc., F.R.S. *Secretaries:* Professor Edmund Johnston Garwood, M.A., and Arthur Smith Woodward, LL.D., F.R.S. *Foreign Secretary:* Sir Archibald Geikie, K.C.B., D.C.L., LL.D., Sc.D., Pres.R.S. *Treasurer:* Aubrey Strahan, Sc.D., F.R.S.

CORRESPONDENCE.

SCANDINAVIAN ICE-SHEETS AND BRITISH GLACIAL DRIFTS.

Sir,—I am glad to see that Mr. Deeley has applied the results of Captain Scott's Antarctic expedition to the supposed extension of a Scandinavian ice-sheet to the British coasts, because it shows that the advocates of this hypothesis are abandoning the policy of "letting severely alone" the difficulty of the Norwegian Channel. Thus I regard his letter as a real advance towards the settlement of a very complex problem. But does not his idea of a floating ice bridge also involve some serious difficulties? Let us assume the sea-level during this part of the Glacial Epoch to have been the same as its present one. We may take the depth of the channel round the southern end of Norway to be from 1,500 to 1,800 feet (see Geol. Mag., 1899, p. 282, for the variations). But the North Sea is generally not more than 250 feet deep, and occasionally only 50 feet (id., 1901, p. 187); the breadth of the channel is about 30 miles, and the distance from the Naze of Norway to Cromer about 400 miles. Let us suppose the top of the Scandinavian ice-sheet to have been only 100 feet above sea-level at the 'bridge'; then, according to Captain Scott's estimate, its total thickness must have been at least 600 feet, or the bottom of the ice-sheet some 300 feet below the margin of the North Sea plateau. Thus it must either have been forced up and over an undulating floor for over 350 miles before it reached the English coast, or its movement have been practically restricted to the upper layers. The latter hypothesis demands a greater viscosity in ice than seems probable to me, though I always thought Forbes nearer than Tyndall to the truth in their well-known controversy. The former presents several difficulties, a full discussion of which would be impossible in the limits of a letter; so I content myself with saying that we must be cautious in resorting to the Antarctic or even to Greenland for a picture of Scandinavia in the Great Ice Age. The general level of the last country may be higher, and precipitation on it may have been greater, than in Greenland, but it is much narrower; in fact, its breadth

in the part with which we are now concerned is about that of the other country in lat. 64° N., and its watershed (though the snow-parting may have been somewhat east of this) is roughly 80 miles from the west coast. In the Antarctic during that 300 miles journey southwards from Mount Erebus, Captain Scott's party was travelling almost parallel with a mountainous region (generally within a few leagues) ranging from 8,000 to 12,000 feet in height, and their view to the south when they turned back was blocked by a snowy mass nearly as high as Monte Rosa. The mean temperature also in the Antarctic is much lower than we are entitled to assume for Scandinavia in the Glacial Epoch (*Ice Work*, pt. iii, ch. i; the probable minimum limit may be inferred from the statements on p. 237). There are other difficulties, such as the relative sizes of Scandinavian and British ice-sheets, the transport and distribution of boulders, the materials of British drifts and their arrangement, which will have to be considered; but the main one for our present purpose is the inadequate 'ramming' power of the ice from the Scandinavian upland, because by far the greater part of the journey to England would have been over land, not by floating on water. Assuming a lower strand-line increases our difficulties, and a materially higher one will submerge more or less of England.

T. G. Bonney.

Cambridge.
March 15, 1909.

THE TRIMINGHAM CHALK—SOUTH BLUFF.

Sir,—I have recently been convinced that the northern part of the bluff is continuous under the sand with the southern part, and in fact offers a section of the greater part of the 'sponge beds' and of some of the succeeding beds. This was first suggested by the presence of the four-angled variety of *Serpula canteriata*, whose known range is otherwise so rigidly restricted to the 'sponge beds' and immediately succeeding beds. Following up this clue, I saw that the very ill-defined lower flint lines of the northern part could be read into accurate correspondence with the flint lines which even in the admirable horizontal section of the 'sponge beds' afforded by the foreshore are not over well defined, while one of the principal hardened beds on the foreshore could be identified in the bluff. I also saw that the main face of the northern part gave a section practically along the axis of the main fold, while the dips in the southern part, from which I argued in 1900 that if the two parts were continuous *Ostrea lunata* chalk must appear within reach in the northern part, were taken from sections parallel with the axis of the fold but some way down its side. This and a local increase in the rate at which the fold rises, which was shown by the recently cleared end of the southern part, would carry the *O. lunata* chalk of the southern part well out of reach in the northern part, but I judged from the upper flint lines that if I was correctly identifying the 'sponge beds', *O. lunata* chalk should come in at the highest point, and I was able to get near enough to the highest point to scoop away a little chalk in which I found

O. lunata. (The single specimen of *O. lunata* recorded from the lower beds in 1906 was found in a detached piece of chalk lying on a ledge about 5 feet up, which I then felt bound to assume against my own views to have been detached from the chalk against which it actually lay, but it is now obvious that it must have slipped down from above.)

I have also discovered that 4 inches above the highest flint band figured on the southern part there is a sudden but apparently conformable change from white chalk with *O. lunata* to grey chalk without *O. lunata*. Of this grey chalk a maximum of 18 inches is preserved, containing one definite line of very curious flints. It is a reasonable supposition that this grey chalk is the lowest part of that grey chalk which is the lowest member of the other main series, and that it supplies the hitherto missing link between the two series.

R. M. Brydone.

27, Twyford Mansions, W.
March 13, 1909.

THE DISCUSSIONS AT THE GEOLOGICAL SOCIETY.

Sir,—I write to strongly express the hope that the suggestion of Dr. Charles Davison, in the February Geological Magazine, that the reports of discussions of papers read before the Geological Society should be printed exclusively in the Proceedings will *not* be adopted. Personally I find it very difficult to keep track of and insure the complete collection and preservation of the Proceedings, which I regard as of an ephemeral character and do not consider worth binding. If the discussions are omitted from the Quarterly Journal the report will be incomplete, and many valuable suggestions may be either lost entirely or only preserved by those paragons of method who bind the Proceedings. I would suggest that those who take part in the discussion should be requested, when proofs of the report of their remarks are submitted to them, to eliminate from them everything except what they believe, on mature reflection, to be of value, and that as far as possible the official reporters of the Society should act on the same principle. Then the discussion may be printed in the Quarterly Journal. I think a paper which when printed *in extenso* is materially damaged by the report of the discussion cannot be worth much. I have so great a respect for the views of Dr. Davison on most subjects that I regret to differ from him in this case.

Bernard Hobson.

Thornton Didsbury, near Manchester.

OBITUARY.

PERCEVAL DE LORIOL LE FORT.

Born July 24, 1828. Died 1908.

We regret to record the death (which took place last year at Geneva) of the eminent Swiss Palæontologist, de Loriol, President of the Swiss Palæontological Society, an indefatigable worker for

nearly fifty years on Mesozoic and Tertiary Invertebrata, and especially distinguished for his researches on the Jurassic echinoidea and crinoidea. As early as 1861 he published "Description des animaux invertébrés fossiles contenus dans l'étage néocomien moyen de Mont Salève". Soon afterwards he was at work with E. Pellat on the Upper Jurassic fossils of Boulogne-sur-Mer, on which they issued a series of joint monographs. He aided Pictet with his *Matériaux pour la Paléontologie Suisse*, and later (1882–9) he described the Jurassic crinoids in the continuation of d'Orbigny's *Paléontologie Française*. He was associated also in joint memoirs with other workers: Cotteau, Choffat, Desor, Ernest Favre, Gilliéron, Girardot, Royer, Schardt, and Tombeck. Of independent works may be mentioned his *Échinologie Helvétique*, *Monographie des Crinoïdes fossiles de la Suisse*, and descriptions of Tertiary echinoids from Egypt and Portugal. He wrote also a monograph on the fossils of the zone of *Ammonites tenuilobatus* (to which attention was drawn in the Geological Magazine for 1878, p. 354, and 1882, p. 279). Some of these memoirs were contributed to the Physical and Natural History Society of Geneva, the Society of Natural Science of Neûchatel, and the Swiss Zoological Review, while others in later years were published by the Swiss Palæontological Society. De Loriol was elected a Foreign Correspondent of the Geological Society of London in 1894.

HUGH LEONARD.

Born 1841. Died February 16, 1909.

The death of Mr. Hugh Leonard, following close upon that of Mr. G. H. Kinahan, removes another link with the Irish Geological Survey as it stood up to the time of its severance from that of Great Britain in 1905.

Mr. Leonard was appointed Assistant Geologist in August, 1867, and, under the guidance of Mr. Kinahan, surveyed large tracts of the complicated areas of Mayo and Galway in the west of Ireland, subsequently mapping a considerable portion of county Cavan, and finally revising the survey of the interesting district about Enniscorthy, in co. Wexford. His mapping, always careful and accurate, has withstood the brunt of latter-day revisions, while his accompanying memoirs are clear and explicit. Possessed of a first-class knowledge of chemistry, he made good use of this science as an aid to his geological researches. Unfortunately an accident, sustained in the course of field-duties, deprived the Survey of Mr. Leonard's services in the year 1881, when he retired on a specially granted superannuation. He was for many years a Fellow of the Geological Society, an active Member of the Royal Irish Academy, and, up to the time of its dissolution in 1889, he acted as Honorary Secretary of the Royal Geological Society of Ireland. Of a kind, helpful, and cheerful disposition, he was greatly esteemed by the many who enjoyed his friendship. He passed away after a brief illness at his residence, Blackrock, co. Dublin.

R. Clark.